THE ENGINEER

A Seven-Day Journal

The Advisory Council on Scientific Policy

THE fourth annual report of the Advisory Council on Scientific Policy was published as a White Paper (Cmd. 8299) on Wednesday morning last. Sir Henry Tizard, F.R.S., is the chairman of the Council, which, in the period April, 1950, to March, 1951, held nine meetings. The report presents the Council's observations on such matters as scientific manpower, higher technological education, Government scientific organisation, the Colombo Plan, scientific libraries and technical information services, atomic energy and priorities in research. On the subject of atomic energy, the report records that a committee of the Council has considered the possible industrial uses of atomic power and their probable economic value. In the view of that committee, there is a reasonable prospect that atomic power can be developed on a large scale and that the cost would not ultimately differ widely from that of power derived from coal. It is pointed out, however, that a number of technical problems still remain to be solved and that the successful development of an experimental atomic power plant depends largely on metallurgical work, which is now proceeding. After full discussion, the Council has concluded that the development of atomic power stations to the stage when they can contribute substantially to the power resources of the country is likely to take at least a generation. But, the report adds, conditions in other parts of the world may be more favourable to the development of atomic power. For that reason alone, quite apart from other possibilities, the Council thinks that experiment on the civil applications of atomic energy should continue to be pressed forward. At the same time, it is emphasised that such work should not be allowed to retard enquiries into the better utilisation of existing sources of heat and power.

Proposals for an Irrigation Scheme in the Jordan Valley

A REPORT on a proposed irrigation scheme in the Jordan valley, prepared for the Jordan Government by the consulting engineers, Sir M. MacDonald and Partners, has just been published. The main object of the proposals is to absorb as many Arab refugees as possible into the national economy on a permanent footing, as well as to add materially to the agricultural production and economic stability of the whole kingdom. The diversion and storage of the Rivers Jordan and Yarmuk is envisaged, at an estimated cost of £23 million, to give eventually a perennial irrigation of 555,000 donums (one donum is equal to a quarter of an acre). The area affected by the proposed developments lies between Lake Tiberias to the north, and the Dead Sea to the south, along the relatively flat river valley, known as the "Ghor," through which the River Jordan flows between these two lakes. Feeder canals would be constructed beside the river, one for the Eastern Ghor and one for the Western Ghor, along substantially the whole of the length from Lake Tiberias to the Dead Sea; alternative proposals to give sufficient storage capacity include modification of the existing dam at the outlet of Lake Tiberias, and the construction of a reservoir to regulate the flow of the Yarmuk. It is estimated that the entire scheme would take sixteen years to complete, employing 6000 to 7000 men, and the proposals have been formulated in four stages. The first stage would provide perennial irrigation for 189,000 donums on the Eastern Ghor from the River Yarmuk, through a diversion canal 70km long. The second stage would provide winter water for 110,000 donums in the Dead Sea region. The water would be drawn from the winter flow of the River Yarmuk coming through the first stage canal, which would be lengthened by 26km. In stage III the winter flow of the River Jordan would be stored in Lake Tiberias, to provide water to complete the perennial irrigation of the east side of the Jordan from the Yarmuk to the Dead Sea. This would add an additional 56,000 donums to the irrigated area, and would also provide water for the irrigation of 104,000 donums in Israel. Stage IV is estimated to irrigate 200,000 donums on the west side of the Jordan in the Jericho area, by storing the winter flow of the Yarmuk.

The Engineering Advisory Council

THE Minister of Supply, Mr. G. R. Strauss, was asked in Parliament on Monday last if he would give a report of the work of the Engineering Advisory Council, and would say on what dates this year the Council had met. In reply, the Minister stated that the Council had met on four occasions during the present year, and had discussed a variety of subjects. The matters considered by it had included ways of increasing productivity, education and training in industry, research and development, exports, foreign competition, European recovery and co-operation, joint consultation, the electricity supply position, metal supplies, and the impact of rearmament on the engineering industry. The Minister went on to say that the Council had proved most useful to him and, he believed, to industry as a medium for exchange of views, particularly on those aspects of Government policy which affected the engineering industry. It may be recalled that the Engineering Advisory Council was constituted early in 1947 to provide for the Minister of Supply a means of consultation with employers and workers on "matters of general concern in the engineering field." Matters normally handled by the joint organisations of employers and trades unions in connection with wages and working conditions do not come within the scope of the Council's activities. Both sides of industry are represented on the Council, but reports of its deliberations are not published. Summaries of its discussions are, however, circulated to employers' organisations and trade unions.

British Railways' Appointments

THE Railway Executive has announced the appointment of new mechanical and electrical engineers in the London Midland, Eastern and North-Eastern, and Western Regions of British Railways. The engineers selected for these posts are Mr. J. F. Harrison, M.I.Mech.E., M.I.Loco.E., Mr. K. J. Cook, M.I.Mech.E., M.I.Loco.E., and Mr. R. A. Smeddle, M.I.Mech.E., M.I.Loco.E. Mr. Harrison entered the Doncaster works of the old Great Northern Railway in 1921 and was appointed assistant chief mechanical engineer of the L.N.E.R. at Doncaster in 1947. Since February, 1950, he has been mechanical and electrical engineer, Eastern and North-Eastern Regions, and is now transferring to the London Midland Region. Mr. Cook, who goes to the Eastern and North-Eastern Regions, was trained at the Swindon works of the G.W.R., where he became a premium apprentice in 1912. He was appointed principal assistant to the chief mechanical engineer of the G.W.R. in 1948 and mechanical and electrical engineer of the Western Region in January, 1950. Mr. Smeddle, who now becomes mechanical and electrical engineer of the Western Region, began his railway engineering career as a pupil with the North-Eastern Railway in 1919. He was appointed mechanical engineer, L.N.E.R., at Darlington in 1941, and since October, 1949, has been deputy mechanical and electrical engineer in the Southern Region of British Railways.

The Technical Personnel Committee

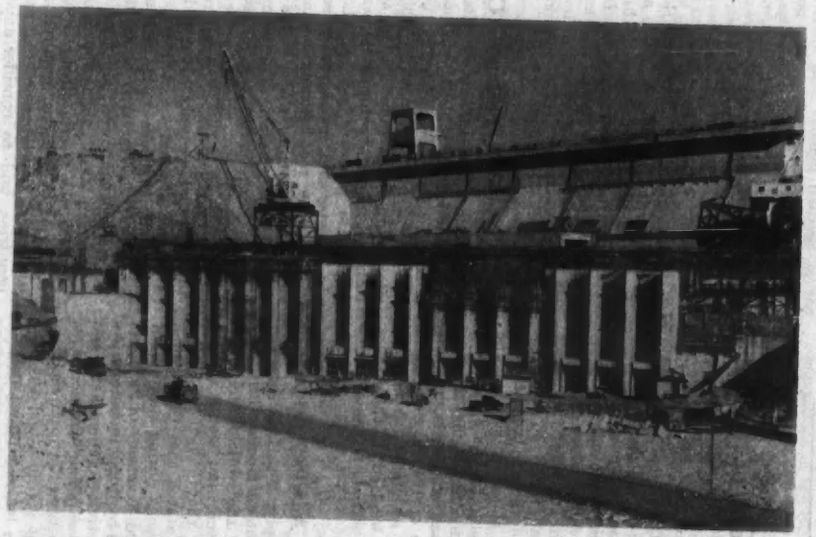
THE Minister of Labour, Mr. Robens, stated in Parliament on Thursday of last week that it had been decided to reconstitute the Technical Personnel Committee, which dealt so successfully with questions of scientific and technical manpower during the war and in the immediate post-war period. Lord Hankey, the Minister said, had agreed to serve as chairman of the reconstituted committee, which would have rather wider terms of reference than its predecessor. The committee would review the requirements for scientists and engineers at home—especially the requirements arising from the defence programme—in relation to the available supply. It would also consider what more could be done to meet certain important overseas needs for engineers and scientists. In the latter connection, the terms of reference empower the committee "to make recommendations upon appropriate steps to promote the recruitment from the United Kingdom of persons required to assist the economic development of under-developed countries, and to consider any special steps required to provide opportunities for training in the United Kingdom of persons from under-developed countries."

Agricultural Machinery at the Science Museum

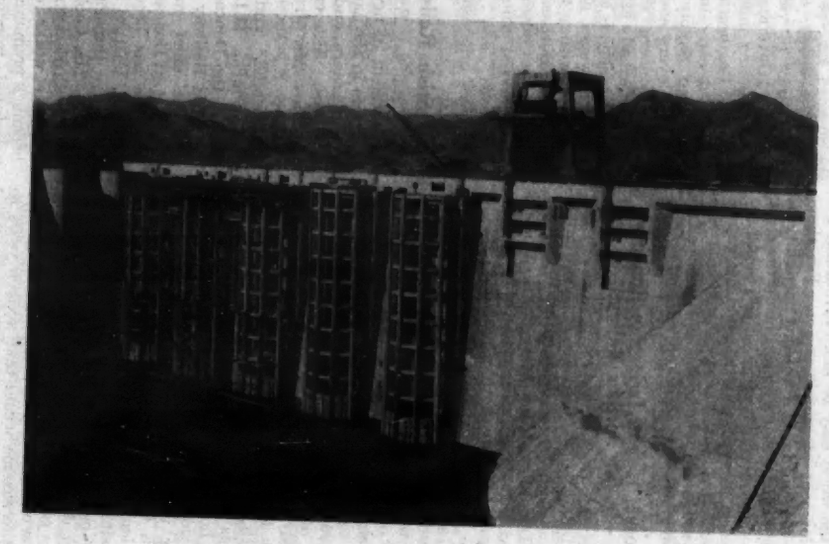
THE agricultural machinery collections at the Science Museum, South Kensington, were reopened on Wednesday of last week by the Minister of Education, Mr. George Tomlinson. These collections, which were started in 1857, were removed to the country for safety in 1939, and then, during the war, the Museum lost the space which they had hitherto occupied. Now the collections have been rearranged on the first floor of the new east block of the Museum building, and have been extended to cover the developments made in farm mechanisation during the past twelve years. In the new building, modern display methods have been devised by using controlled fluorescent lighting. Modern agricultural machinery developments are illustrated by a series of about 100 models, all to a scale of 1in to 1ft, which have been provided by various machinery makers. They are effectively displayed against scenic backgrounds with plaster bases, and illustrate the work of the fully mechanised farm throughout the different seasons. As a centre piece to this part of the collection, there is a full-sized sectioned combine harvester. Other original exhibits include a group of ploughs, Patrick Bell's reaping machine of 1826, and the Ivel farm tractor of 1902. The latter, which was designed and constructed by Mr. Daniel Albone, of Biggleswade, was the first medium-powered farm tractor in this country to be driven by an internal combustion engine. It is still in working order and was included in the parade of agricultural tractors at this year's Royal Show at Cambridge. An illustrated description of the tractor was given in our issue of July 13th. At present the display at South Kensington covers arable farming only, but as further space becomes available it will be extended to include other departments of agriculture.

THE DAVIS DAM UNDER CONSTRUCTION

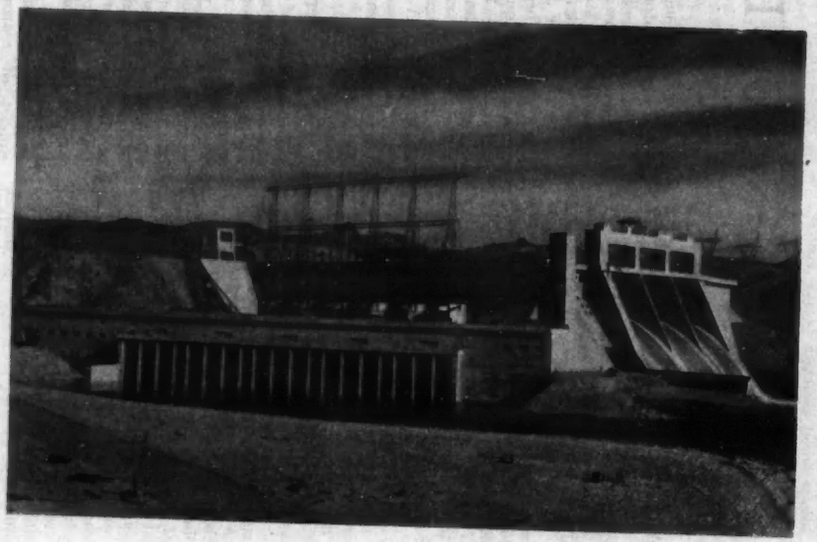
EARLY CONCRETING OPERATIONS, SEPTEMBER 1949



DOWNSTREAM FACE APPROACHING COMPLETION, OCTOBER 1949



UPSTREAM VIEW OF INTAKE STRUCTURE, OCTOBER 1949



COMPLETED CONCRETE STRUCTURES, DECEMBER 1950

THE ENGINEER

The Davis Dam Project, U.S.A.

No. III—(*Continued from page 108, July 27th*)

Concrete Mixture

INTERESTING details of the siliceous admixture which was specified by the Bureau of Reclamation for the concrete used at Davis dam have been given by J. L. Gilliland and W. T. Moran.* Siliceous admixtures were first used by the U.S. Bureau of Reclamation in 1912–16, when a "sand-cement" was used in the construction of Arrowrock dam, on the Boise River in Idaho, and of Elephant Butte dam, on the Rio Grande River in New Mexico. The cement used at Arrowrock dam was a blend of 45 parts of granite to 55 parts of normal cement, interground in tube mills at the dam site to a fineness of 90 per cent passing a 200-mesh sieve. At Elephant Butte dam, the cement was a blend of 48 per cent sandstone and 52 per cent Portland cement, prepared in a similar manner. Recent examinations show that the dams have suffered little disintegration, except for the downstream face of Arrowrock dam, where the continuous spray from the outlet works brought about a severe freezing and thawing exposure.

High-silica cement prepared from calcined shale and Portland cement was proposed for the construction of Hoover dam. At that time, the question of an adequate supply of the high-silica cement influenced the decision to use the then newly developed low-heat Portland cement. There was no assurance that high-silica cement was available in quantity from more than one producer, while, on the other hand, all manufacturers were able to furnish low-heat Portland cement. The large size of Grand Coulee dam caused the Bureau to consider the advisability of using a Portland-pozzolan cement, and to investigate the possible sources of active materials. Several suitable materials were found, but the supply of Portland cement was found to be adequate for the proposed construction rate, and at a price which eliminated any economic grounds for using pozzolans. However, the information gained from investigations of materials of this nature provided a valuable background for the subsequent use of pumicite at Friant dam in California, and at Altus dam in Oklahoma. Both the Friant and the Altus pumicite deposits were unconsolidated and naturally fine, so that no processing was required. At Altus dam, the amount of pumicite used was 35 per cent by weight of the Portland cement. At Friant dam, 20 per cent by weight was used.

The original and most distressing experience of the Bureau of Reclamation with the problem of alkali-aggregate reaction was at Parker dam, on the Colorado River. Other structures built with aggregates from the same source show the characteristic cracking where high-alkali cement was used. Hence, in those localities where the aggregate deposits contain sufficient reactive material to constitute a problem, low alkali cement is now being specified as a matter of course. Another approach in cases where low-alkali cement production capacity is limited has been to utilise admixtures that will react with the cement alkali and thus prevent subsequent expansion. Such admixtures usually consist of fine siliceous materials.

Petrographic examination showed that 45 per cent of the coarse aggregate (larger than ¾in) used at Davis dam was deleterious, i.e., reactive with high-alkali cement. Mortar bar tests indicated excessive expansion for combinations of the sand and high-alkali cement. Thus, on account of the nature of the aggregate in the vicinity of Davis dam, the use of a low-alkali cement in the concrete was considered mandatory. Of the materials that had been investigated, certain shales from Southern California (Monterey shale and Puente shale), calcined to increase the activity of the resultant product and to reduce the mixing water requirement, were found to be outstanding in counteracting the alkali-aggregate reaction. Fortunately, the Puente shale was geographically available near the Davis dam site, and it was used to replace about 20 per cent by weight of the Portland cement. The following table shows data relating to a typical concrete batch used at Davis dam :—

Ratios	
Water to cement plus calcined shale	0·62
Aggregate to cement plus calcined shale	9·48
Gravel to sand	3·00
Material Quantities	
Cement (pounds per cubic yard)	309
Calcined shale (pounds per cubic yard)	62
Water (pounds per cubic yard)	215
Sand (per cent)	25
No. 4 sieve, ¼in (per cent)	10
¼in to 1½in (per cent)	24
1½in to 3½in (per cent)	21
3½in to 6in (per cent)	20

Aggregate water saturated, surface dry.
Resulting slump, 2in.

The word "pozzolan" was purposely avoided in the specifications for the calcined shale for Davis dam. Instead, the material was described as "calcined reactive siliceous material," because it was realised that many pozzolanic materials would not meet the detailed requirements of the specifications. Actually, the detail requirements were deliberately written to describe a kind of material which had been demonstrated to have the desired properties. Calcination was required because it had been found that heat-treatment was necessary to develop these properties to the fullest extent. The specifications may be classified under the following headings :—

(1) Geological description and geographical location of acceptable deposits.

(2) Chemical composition and physical properties.

(3) Activity tests.

Under the first heading, the raw materials from which the siliceous material could be produced was limited to cherty shale, chert or porcelaneous rock. These had to be high in opal content, such as those found in the Monterey formation or other Miocene strata of similar lithology. The Puente formation in the vicinity of Pomona, California, filled the requirements, too. It was required that the raw material should be thoroughly calcined at not ess than 1400 deg. Fah. Limits on chemical composition and physical properties are shown in the following table :—

Fineness (square centimetre per gramme)*	Not less than	8000
Specific gravity	Not less than	2·3
SiO_2 (per cent)	Not less than	60·0
Fe_2O_3 (per cent)	Not less than	2·0
Al_2O_3 (per cent)	Not less than	15·0
CaO (per cent)	Not more than	10·0
MgO (per cent)	Not more than	4·0
$Na_2O + K_2O$ (per cent)	Not more than	4·0
Water-soluble material (per cent)	Not more than	1·0
Water-soluble alkali (per cent)	Not more than	0·1
Loss on ignition (per cent)	Not more than	7·0
Moisture content (per cent)	Not more than	3·0

* Blaine air-permeability apparatus.

Calcination and fineness were found to improve the activity of the shale, making it more effective in reducing the expansion resulting from alkali-aggregate reaction. The limits of iron oxide and specific gravity eliminated materials such as diatomaceous earth. Other limitations were based on test results obtained on certain shales known to be satisfactory.

The activity tests comprised a strength test, a reduction in alkalinity test, and a reduction in expansion test

(*a*) *Lime-Pozzolan Strength Test.*—The strength test required that the 2in by 4in cylinders made from lime, sand, water and reactive material should have a seven-day strength of not less than 600 lb per square inch after a sealed storage for one day at 70 deg. Fah., followed by six days at 130 deg. Fah. The strength requirements were intended to ensure obtaining a material that would contribute to the continuing strength gain of the concrete, i.e., a pozzolanic material. The lime-mortar strength test had been used previously, particularly in the specifications for Bonneville dam.

(*b*) *Reduction in Alkalinity Test.*—This chemical solubility test was adopted from studies made to establish a rapid chemical

Upstream View of Concreting Operations, November 1948

* "Siliceous Admixture Specified for Davis Dam Concrete," *Engineering News-Record*, February 3, 1949, page 62.

method for determining the reactivity of aggregates with cement alkalies. In this test, the material is allowed to react for twenty-four hours with a solution of sodium hydroxide at an elevated temperature (80 deg. Cent.). The liquid and solid phases are then separated. When used to judge the deleterious character of aggregates, it was found that joint consideration had to be given to the reduction in the alkalinity of the solution, and the quantity of silica dissolved by the caustic solution. When considering the effectiveness of a wide group of pozzolanic materials in inhibiting alkali-aggregate reaction, the same two items had to be considered jointly. However, in the specifications for the Davis dam, a limit was placed on alkalinity reduction only because the activity of the particular shale specified for use was known to correlate directly with the single determination alone.

GANTRY CRANE WORKING ALONG DOWNSTREAM FACE, SEPTEMBER 1949

(*c*) *Reduction in Expansion Test.*—The reason for using a reactive siliceous admixture at Davis dam was to counteract any abnormal expansion. Thus, a specification test to establish the reduction in expansion ability of the material being purchased was a practical test. A basic requirement for any test of this sort was that a uniform supply of deleterious aggregate had to be available. However, natural deposits of reactive aggregates were not sufficiently uniform for this purpose. Inasmuch as natural volcanic glasses constituted one class of reactive aggregates, synthetic siliceous glasses were tried and were found to be highly reactive. The next point was to decide what glass of uniform composition was most readily available. Pyrex No. 774 was chosen. This is the standard Pyrex glass used for laboratory and domestic ware, and for industrial piping. The technique used was to prepare, by crushing, screening and washing, a fine aggregate composed of 20 per cent of each of the five sizes from 8 mesh to 100 mesh. Fines passing the 100-mesh screen were discarded because they tended to reduce the expansion. Mortar bars were made up of high-alkali cement and glass aggregate with the siliceous material under test used to replace 20 per cent by weight of the cement. The bars were stored under sealed moist storage and the expansion determined after fourteen days. Acceptable materials were required to show a reduction of 75 per cent in the amount of expansion compared with specimens made without the siliceous admixture.

Concrete Construction

Concrete work was started late in 1947. Various stages in the work are illustrated herewith. The construction schedule required that the concrete in the forebay channel, the spillway and the intake structure be safely above the diversion channel water level before the river could be diverted. At Davis dam concrete work is said to have been relatively expensive, compared with other American projects requiring about the same volume, because much of the concrete was poured in specialised sections, varying from a few inches to several feet in thickness, with a considerable amount of reinforcing. Furthermore, much equipment was involved in placing the concrete and—because the construction schedule necessarily required the concrete work to be spread over a three-year period—all this plant was tied up for that considerable period. One advantage of the miscellaneous variety of the concrete work was that as the setting up of shuttering and the reinforcing slowed down progress, two 4 cubic yard mixers were able to keep up with the work. Because mixing and batching equipment was difficult to obtain when concrete work at Davis dam was commenced, the contractor bought the facilities used at Fontana dam in Tennessee. This mixing plant was second-hand and much repair and reinforcing work had to be done while it was being set up. For example, a layer of hard face weld approximately ¼in thick was placed on all of the inside surface of the mixers, which required 1450 lb of welding rod for each mixer.

The operation of the plant took place along the following lines. Graded and washed sand and rock were delivered to the top of the batch plant by a 36in belt conveyor. The aggregates were screened and deposited into charging bins. This secondary screening separated aggregates which had been broken in handling so that the classifications more nearly represented true sizes. Cement and admixture were held in two cement storage silos at the batch plant and moved by an air pumping system to charging bins, to be charged independently into the mixer. The materials for a batch of concrete were dropped by gravity from the high charging bins into eight steel batchers suspended on scales. Electric controls automatically regulated the amount of each material. The batch was then charged into one of the two mixers and mixed for two and a half minutes. Concrete was then discharged into buckets loaded on a flat wagon. Four full buckets constituted a load and were hauled by a petrol-driven engine over a standard gauge track mounted on a trestle. Cranes mounted on the same trestle placed the concrete and moved the shuttering, the reinforcing steel, &c. The cranes had 150ft booms, and were capable of lifting 36 tons at a distance of 40ft, from the centre of the crane and 8 tons at a 160ft. distance.

The trestle leading from the mixing plant to the spillway section and thence to the intake section was in the form of an "8" curve. One turn was just before the spillway section it was reached and the other between the spillway and intake sections. The minimum radius of curvature of the inside rail was 120ft and the gauge of the crane tracks was 43ft. The cranes had four sets of wheels and were driven by electric motors geared to two of these sets. Originally, motors were mounted on wheels on opposite sides of the trestle, but on the sharp curve one motor tended to be seriously overloaded and threaten to burn out. This was overcome by the unorthodox mounting of both motors on sets of wheels on the same track, so that there would not be a speed imposed on the motors different from that for which they were designed.

The greater percentage of the concrete was placed from the trestle. Part of the work—such as slope paving and the gravity wall—could not be reached from the trestle, and a mobile crane with a long boom was used as illustrated herewith. After this crane lifted the concrete buckets as high as it could from the bottom of the channel, the remainder of the concrete was placed from the top of the bank.

The 150ft deep forebay channel slopes were paved for a distance of several hundred feet up-channel from the spillway and the intake structure. To anchor the slope paving 1¼in square reinforcing bars were grouted in place to a depth of at least 4ft 6in on centres varying from 5ft to 7ft. These anchors were bent in a hook form so that they would be firmly embedded in the 18in thick slab. In all of the Davis dam concrete work important exposed surfaces were water cured. A white-pigmented curing compound was used for unexposed surfaces, and for those exposed surfaces where appearance is not important.

Because of a requirement that concrete had to be at a temperature of less than 80 deg. Fah. when placed, ice had to be added to the mixing water. With air temperature in the summer exceeding 110 deg. Fah., the concrete frequently reached a temperature as high as 170 deg. Fah. Even though the aggregate was protected from the direct rays of the sun by a shed, it averaged more than 100 deg. Fah. To effect proper reduction in temperature, more than one-third of the required weight of mixing water was added in the form of ice. In a typical 4 cubic yard batch, about 900 lb of water was required. As much as 400 lb of this water was added as ice. By the time the two and a half minutes' mixing period had elapsed, all of the ice was melted and the concrete mix was down to the required temperature. To produce this ice and to reduce the mixing water temperature, three automatic tube ice machines were installed at the mixing plant. This installation was capable of reducing the temperature of about 2000 gallons of water per hour from 70 deg. to 32 deg. Fah. It was also capable of producing 55 tons of crushed ice per twenty-four-hour operating period. The ice was carried on a short conveyor to a bucket elevator which

carried it up to the top of the batching floor. A screw conveyor then took it to the water and ice batchers. This conveyor system was completely enclosed to reduce any loss by melting.

The Davis dam project was designed under the direction of L. N. McClellan, chief engineer of the Bureau of Reclamation. The project was constructed by a syndicate headed by the Utah Construction Company, with T. L. Terry acting as general superintendent.

Apparatus for the Testing of Agricultural Machinery

By H. J. HAMBLIN, B.A.*

THE functions of the National Institute of Agricultural Engineering are to provide a centre for information on all aspects of agricultural engineering, to engage in research and development in the interests of agricultural mechanisation and to carry out impartial tests of implements and machinery as a service to manufacturers. The last-named of these activities, no less than research, requires the use of special apparatus and thus the Institute's testing work has led, and continues to lead, to the development of more and more equipment as the scope of testing widens. In this connection it may be worth mentioning that the volume of this work rapidly increased until, within less than two years of the formation of the N.I.A.E. (replacing the Institute for Research in Agricultural Engineering, at Oxford) in 1942, about 100 machines of all kinds were being tested every year and, in general, it was not practicable to refrain from testing any particular machine until all the apparatus to be desired was available. Instead, the best test that could be contrived with whatever equipment was available was carried out and a process adopted of continually widening the scope of tests as facilities allowed—and, of course, as increased experience suggested. The present article has been written to put on record some of the equipment at present in use; it is limited to what is thought to be the more interesting items among those with the development of which the writer happens to have been associated.

One important point should be borne in mind in considering the equipment described. Most of it is intended for use in the field by any of a number of individuals engaged in test work. It must, therefore, be both robust and, as far as possible, straightforward in principle and practice. A research worker engaged on one particular project has ample opportunity to learn the idiosyncrasies of his apparatus but it is not reasonable to expect a man who is dealing with a series of projects and who has to devote a good deal of attention to purely agricultural considerations, to "fiddle" with apparatus. The right thing is to give him a robust instrument, which, used in the obvious way, will either give him the right answer or, if he has overlooked part of the drill, no answer at all, but which cannot give him a wrong answer. It is with this object in view that the equipment described below has been developed.

Drawbar Dynamometer

One of the first requirements in testing is to measure the draught of an implement or the pull exerted by a tractor. This is done with a drawbar dynamometer the operation of which may be understood by reference to the photograph of a cut-away model shown in Fig. 1. The drawbar pull is converted into oil pressure and read directly on a specially calibrated gauge, an adjustable damping valve being provided, as experiments have shown that the range of load variations encountered in practice is far too great for it to be possible to use a fixed damping device. Three ranges of pull are normally provided for: 0-2500 lb, 0–5000 lb and 0–10,000 lb. Pulls of up to 20,000 lb are measured by using two dynamometers coupled mechanically in parallel, with a common oil line. The dynamometers are machined from alloy steel bar, the maximum working stress being 10 tons per square inch.

It will be noted that the dynamometer is strongly constructed and that it has a fairly large oil capacity, so that it continues to function even when some oil has been lost by leakage. SAE20 oil is used and, with static loads, friction of the plunger causes a full load difference of the order of ±2 per cent in the reading, the sign depending on whether the load is being applied or released. For this reason gauges are calibrated on a pressure gauge tester and not by applying test loads, but the instrument can be used for weighing dead loads either by applying the loads carefully and using the appropriate calibration curve or, more practically, by manual rotation of one part of the dynamometer before taking a reading. In the field, friction only serves to augment damping. The dynamometer can be used either for direct reading with a gauge or in conjunction with recording equipments of which several, both continuous and short-running, have been made and used from time to time. Direct-reading dynamometers based on this design are now being manufactured commercially by two firms in this country.

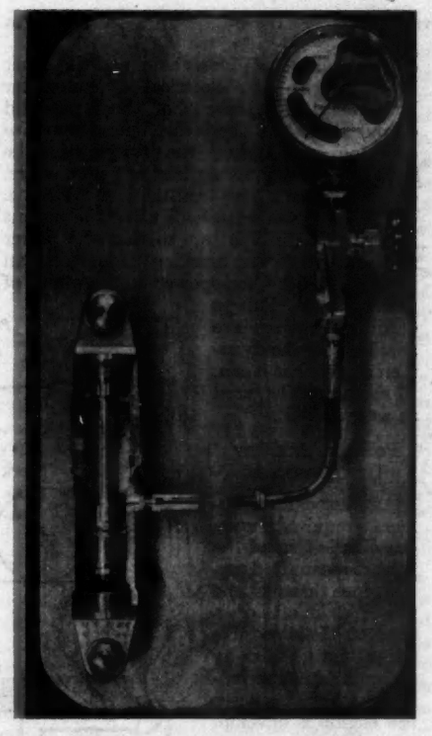


FIG. 1—DRAWBAR DYNAMOMETER

Electrical Loading Car

The second requirement when testing tractors is a means of applying a drawbar load, which can be varied at will. Agricultural implements can be used as a load but the range and degree of control are not usually all that could be desired and, further, it is not always desirable to cultivate the land used during a test. An electrical loading car is one of the most satisfactory means of providing a load and one was built for the World Tractor Trials in 1930. A second, somewhat lighter, car was built in 1946, incorporating some refinements. A view of the interior of the car, showing the instruments and controls and the pressure gauge of the dynamometer is given in Fig. 2.

The loading car is built around the transmission of a tractor. From the belt pulley shaft of the tractor transmission a chain drive is taken to a generator mounted at one side of the cab. The generator is separately excited, the field current being provided by a petrol-engine driven exciter set at the rear of the car (Fig. 3). The output of the generator is absorbed by resistances located behind the cab, control of the load being obtained by three knife switches putting different amounts of resistance in the generator armature circuit and by a rheostat controlling the generator field current. Varying forward speeds can be accommodated by means of the gearbox in the transmission because the belt pulley drive on a tractor is taken from the input shaft to the gearbox; thus, changing gear in the box of the transmission used alters the ratio between the speed of the rear wheels and that of the generator. It will be noted that large diameter (13–40) pneumatic tyres are fitted to the loading car and that there is a rear clevis. This is connected to the hitch by a member passing right through the car so that additional load can be attached behind when necessary.

The load control with this car is extremely close. The earlier car was equipped with a self-excited shunt-wound generator and control was not very satisfactory. In particular, when determining the maximum sustained pull of a tractor it was difficult to avoid losing the excitation and thus all control, as the forward speed of the tractor was reduced. No such difficulty is encountered with the 1946 car; indeed, the control was found to be so sensitive when the car was completed that a project for making an automatic load-controller, to maintain the load at any predetermined value, was forthwith abandoned as an unnecessary refinement.

Fuel Measuring Apparatus

The apparatus used in the field for determining the fuel consumption of a tractor is of interest, not so much in itself, as because of the technique for which it was developed. The object of a field fuel consumption test is to determine the specific fuel consumption (quantity per drawbar horsepower-hour) of a tractor in each of its working gears over the full range of pulls that it can exert in that gear. Experiments showed that constant-volume methods of measuring fuel gave very erratic results even on land which appeared to be flat, because small differences in level affected the results of runs of different lengths by different amounts. It was finally proved that consistent results could only be obtained

* National Institute of Agricultural Engineering

by measuring the total fuel used in travelling both ways along a measured distance at each drawbar pull and this is now standard procedure, a distance of 500ft being normally used, giving a total run of 1000ft.

The problem then was how to measure varying quantities of fuel accurately without affecting the head of the fuel supply to the engine, which is obviously undesirable when testing. The apparatus is mounted on one side of the tractor, as can be seen in Fig. 3, with the fuel bowl at the same height as the main fuel tank. The test run is made on this bowl, the engine being switched over to the main tank for turning after the outward run over the measured distance. At the end of the double run, the bowl is filled up to a fixed mark with fuel from the long calibrated tube above. Accuracy is obtained from the length of this tube, but the fuel supply head is normal during the test run. The hand pump on the right is used to replenish the tube with fuel from the main tank.

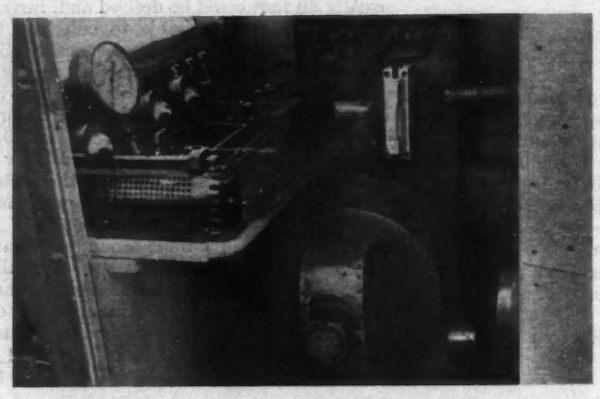


FIG. 2—INTERIOR OF DYNAMOMETER CAR

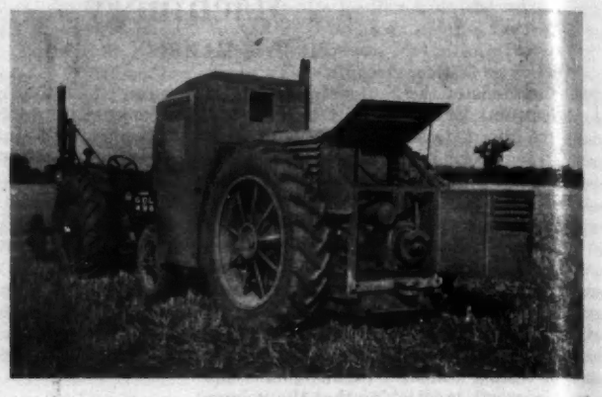


FIG. 3—ELECTRICAL LOADING CAR

BELT TRANSMISSION DYNAMOMETER

Belt tests of tractors are made with conventional swinging-frame electrical loading dynamometers. Similar dynamometers, running as motors, can sometimes be used for measuring during a test the power required to drive agricultural machinery, such as hammer mills, designed to be belt driven by a tractor or electric motor; but this is not possible when the site of the test is such that a suitable power supply is not available. In these circumstances the machine under test is driven by a tractor through a belt transmission dynamometer which measures the torque being transmitted by reversing its direction through a gear and chain assembly carried on a pivoted arm held by a spring balance.

FIG. 4—BELT TRANSMISSION DYNAMOMETER

Fig. 4 shows a belt transmission dynamometer being calibrated against an electrical dynamometer. A tractor is coupled to the input pulley shaft which carries a gear driving a second gear mounted in the reaction frame. The frame is carried on trunnions coaxial with the input (and output) shaft and held by the spring balance. The shaft carrying the second gear drives the output pulley shaft by a chain, and this shaft is coupled to the electrical dynamometer by a belt. The speeds of the input and output shafts are the same, but in opposite directions, and thus the torque on the reaction frame (ignoring friction) is twice the output torque. The transmission is always calibrated by this method, using the output belt required in the test so that the power requirement of the machine under test can be stated as the horsepower at the pulley of the machine. Pulleys of different sizes are available for the dynamometer so that it can, if necessary, be used as a speed jack.

POWER TAKE-OFF DYNAMOMETER

Another measurement required upon occasion is that of the power transmitted to a machine through the power take-off of a tractor. It is possible to estimate this by determining approximately the horsepower the engine is developing, by some such method as measuring the induction manifold depression, and also measuring the drawbar horsepower. The power take-off power can then be estimated by assuming values for wheel and gear efficiencies, but the result can only be very approximate. A dynamometer has been recently developed to enable more accurate measurements to be made. In essentials, it consists of two halves of a coupling, one carried on the existing power take-off shaft of the tractor and the other integral with the new output shaft. Plungers in the first half bear on ball bearings carried by the second half and the torque transmitted is measured by oil pressure under the plungers. Fig. 5 shows, diagrammatically, the arrangement by which the oil pressure is transmitted to a pressure gauge and also the principle of operation of the control unit to be seen on the right of the tractor footplate in Fig. 6. The control unit acts as a safety valve to prevent damage to the gauge in the event of a sudden overload and also replenishes the oil in the dynamometer whenever the tractor is declutched. This is accomplished by the spring-loaded plunger forcing oil through the non-return valve; it is a necessary provision because of the small displacement of oil required to allow the plungers to bottom.

Unlike the hydraulic drawbar dynamometer, the power take-off dynamometer does not give two calibration curves with increasing and decreasing loads because the cyclical variation of torque results in a mean value being recorded, irrespective of the way in which the load is applied. The one source of error in the instrument is the varying radius of the point of contact of the ball bearings and the plungers. This results in a possible error of ±1·1per cent from a mean calibration, according as to whether the plungers are right out or right in, but the error in practice will normally be well within these limits because the plungers can never be in the fully out position when torque is being transmitted, and the instrument is unlikely to be run long enough between successive declutchings for them to reach the other extreme position. Greater accuracy could

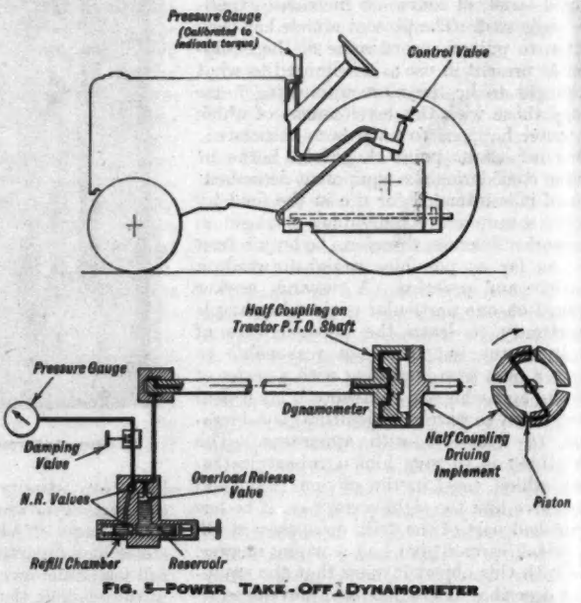


FIG. 5—POWER TAKE-OFF DYNAMOMETER

be obtained by adopting a set procedure for taking individual readings and calibrating by using the same procedure, but the accuracy using a mean calibration is sufficient for most purposes. With this instrument separate readings of torque and speed are obtained from the instruments in front of the tractor driver; the extra gauge on the left is coupled to a drawbar dynamometer incorporated in the tractor drawbar.

Laboratory Freeze Drier

An entirely different problem from those so far described arose in connection with the testing of grass driers and led to the development of a laboratory freeze drier. The problem was how to determine the feeding value (particularly the protein and carotene content) of samples of wet grass fed to a drier during a test carried out at a site perhaps 100 miles away from the Institute. Wet grass samples would deteriorate at normal temperatures, and it was finally decided that the only way of dealing with

Fig. 6—Power Take-Off Dynamometer

the problem was to store the samples in double-sided containers packed with solid carbon dioxide and then, when they reached the laboratory, to dry them by placing them in a high vacuum and condensing the water drawn off.

This technique of freeze drying, which was very successfully used on a larger scale during the last war for the preparation of dried blood plasma, had been adopted by some research workers for drying small samples of grass, but not on a sufficiently large scale for the Institute's requirements. Thus no standard apparatus was available and the freeze drier now used was accordingly built, with the helpful advice of research workers who had experience of the technique and a firm manufacturing equipment for drying blood. Details of the freeze drier are shown in Fig. 7. Samples, in open Kilner jars, are placed in pockets in a tray. The tray is then pushed under the top part of the drying chamber and raised by depressing the handle at the rear. Just before the toggles raising the tray reach top centre the top part is lifted off its supporting column and an effective seal is made between it and the tray. The copper condenser fits inside the cylindrical part of the top of the drying chamber and contains white spirit to which solid carbon dioxide has been added. A vacuum pump is connected to a point at the top of the cylindrical part of the drying chamber and a Pirani gauge attachment is provided above the tray.

It will be noticed that the two seals, between the tray and top part of the drying chamber and between this and the condenser, are made without the use of clamps of any sort. This has proved entirely successful, an Edwards "Speedivac" No. 2550 pump being capable of reducing the pressure in the drying chamber, when drying without heat other than atmospheric, to 0·07mm of mercury. In normal use nowadays heat coils, each absorbing 10W, are wound round each pocket of the tray, and, when drying, the pressure drops rapidly to 0·1mm and eventually reaches 0·05mm or lower. The batch of twelve samples takes about ten hours to dry from an original moisture content of 60 to 85 per cent to a final moisture content of about 5 per cent. The moisture removed forms a cap of ice on the end of the condenser, which is torpedo shaped so that formation of ice does not restrict the annular space between the condenser and the surrounding cylinder.

Trailer Weighbridge

Another problem arising in the testing of grass driers is that of accurately weighing trailers of wet grass going to the drier. The problem of weighing trailers arises also, of course, in other applications, but it is particularly troublesome in grass drier testing because an attempt is made to estimate the loss of dry matter occurring in the drier as a result of burning or mechanical loss, and this demands a high order of accuracy in weighing. The dry matter going into or coming out of a drier is calculated from the input rate of wet material or the output rate of dry material, and the moisture content of the wet or dry material. Relatively small errors in any of these measurements may result in a considerable error in the estimation of the loss of dry matter. Thus, the general problem of weighing trailers has been considered with special reference to the accuracy required for grass drier tests and the outfit shown in Fig. 8 was built as a prototype for use during last year's grass drier testing season.

In the past, commercial devices for measuring the load carried by individual wheels have been used, but they have been found to be far from satisfactory, partly because they require to be used on a good surface and require fairly accurate location with reference to the wheels, and partly because they are too susceptible to damage. The time factor is often important in a grass drier test because the drier must be kept operating normally, and it may not be practicable to hold up a trailer for more than one or two minutes for weighing. This consideration immediately eliminates many possible methods of tackling the problem and was one of the main reasons why it was decided that the best solution would be to have a weighbridge which could be taken to and erected at the site of the drier.

In use, the weighbridge is supported on four small weighing machines (supplied by S. Parsons and Co., Ltd., of Bradford), each of 2 tons capacity by 2 lb. This is a more practical arrangement than trying to support the whole deck on one system of levers because it keeps the height of the deck above the ground as small as possible and, in any case, probably gives a smaller total weight. For transport, the stiffening members on each side of the deck are removed and the two ends of the deck are raised to form the sides of a trailer, spring buffers under the main deck helping to reduce the effort required. The two wheel arms and wheels and the drawbar are then put on, the jacks raised and the trailer is ready for transport. The suspension is unusual, the wheels being on arms pivoted forward and supporting the trailer by leaf springs acting

Fig. 7—Laboratory Freeze Drier

on the underside of the sides of the trailer. This arrangement was adopted to keep the floor of the trailer as low as possible and thus save time in setting up on site.

After preliminary trials and use for one season, a number of points of detail were noted where improvements could be made, but there seems little doubt that, in principle, the trailer weighbridge is a very attractive solution of the problem of weighing trailers. It can be set up in a convenient position, it requires no careful manœuvring of the trailers and the balancing of the four weighing machines can be accomplished quite easily in about a minute. The accuracy is all that could be desired because it is possible to weigh to half the small divisions on the steelyards and thus to within 4 lb for the total weight.

Single-Wheel Tester

The single-wheel tester, which is being developed primarily for use in research work on tractor driving wheels, is included because it is intended to be used also, when necessary,

Fig. 8—Trailer Weighbridge

for comparative tests of wheels. At present tests carried out for manufacturers to compare, for example, a new tyre tread with the previous pattern, or to show the value of special strakes or other attachments for improving adhesion are made with standard tractors fitted first with one set of wheels and then with the other. The objection to this method is that, although it gives a straightforward comparison of the per-

centage slip with the two types of wheel at various drawbar pulls, it does not give a clear picture of the difference in rolling resistance. In fact, differences in rolling resistance are only reflected in differences in maximum drawbar horsepower and maximum sustained pull in the higher gears and it is very difficult to make an accurate estimate of them. What is really required, for test purposes as well as research, is a method of determining accurately the overall efficiency of a wheel on any land conditions. This is the purpose of the single-wheel tester shown in Fig. 9.

FIG. 9—SINGLE-WHEEL TESTER

Although, as will be noticed from the photograph which was taken during a preliminary trial, the apparatus is not yet fully completed, the wiring being only temporary and the recording gear not in position, it is simply a logical development of that used by the Oxford Institute in 1939 for research on pneumatic tyres. For this work a tractor was modified so that the reaction between the front axle and the chassis could be measured hydraulically, and the difference between this reaction when stationary and under load was used to determine the input torque to the rear wheels of the tractor. (Of course, with this equipment the efficiency of a *pair* of similar wheels was measured). The objections to this apparatus were: first, the effective radius of the front reaction about the rear axle was large, so that a small error in the difference of the reaction when stationary and under load caused a large error in the measurement of torque; secondly it was difficult to obtain consistent readings for the stationary reaction owing to friction in the hydraulic cylinder, thus increasing the risk of error; and, thirdly, the weight on the rear wheels was continually changing with the drawbar pull. These were serious objections and, although a number of useful results were obtained with the equipment, it was realised at that time that further research work would require improved apparatus. From a research point of view the effect of weight transfer in complicating the interpretation of results is, in itself, not unimportant; the added lack of precision in the measurements meant that it was, in any case, impossible to study the finer points.

The single-wheel tester was designed specifically to overcome these objections. A single wheel is made the subject of experiment and this wheel is mounted on a parallel linkage so that, irrespective of the torque being transmitted, the vertical reaction between the ground and the wheel remains constant. The wheel is driven by an electric motor, power being supplied by the generator mounted over the front of the tractor and driven from the tractor belt pulley. In operation the tractor engine drives the rear wheels of the tractor through the normal gearbox and the single wheel through the electrical system. The single wheel is loaded by speeding it up, the rear wheels of the tractor acting as a brake. Thus the system is regenerative, the tractor engine supplying the losses. The final drive to the wheel is by a worm, which is free to slide axially and the input torque is determined by measuring hydraulically the end thrust of the worm. The thrust exerted by the wheel is measured hydraulically in the member connecting the rear assembly to the vertical rail; the pivots of the parallel linkage are on a frame pivoted on the vertical column carrying the thrust rail, thus allowing the wheel to move forward freely relative to the tractor and compress the oil in the cylinder measuring the thrust.

This piece of equipment has yet to be tried on serious work in the field; indeed, it has yet to be calibrated. But preliminary trial runs indicate that it will function satisfactorily and it is hoped that a considerable amount of useful research work will be carried out with it, quite apart from its application to testing. It will be noted that the sources of error in measuring the input torque on the pre-war equipment have been completely eliminated. The input torque is measured by the thrust on the worm shaft, at a radius of 6¼in, and this measurement has a true zero. Perhaps it should be pointed out, in passing, that the accuracy of measurement of the input torque is not affected by the efficiency of the worm. The electrical equipment for this apparatus was provided by Metropolitan-Vickers Electrical Company, Ltd. The motor is particularly interesting, as it is designed to provide 15 h.p. at speeds of 400/1600 r.p.m.

CONCLUSION

From the foregoing it will be appreciated how the testing of agricultural machinery leads to the development of specialised equipment. The scope of this article has been restricted to work with which the writer has been concerned, but any description of test equipment would be incomplete without a passing reference to the increasing use of electrical strain gauges in this field. Where a measurement of internal stress or of high-frequency stress variations is required, electrical strain gauges or strain gauge dynamometers are ideal, and one group at the N.I.A.E. has done a considerable amount of work in developing this kind of equipment for testing, as well as research work. Then there is a whole field of work which has barely been touched, the building of test rigs in which agricultural implements could be subjected, in the laboratory, to forces and motions such as they encounter in the field. This line of thought is also being pursued, although insufficient data are as yet available for very much progress to be made.

The description of work on these subjects is, however, left to those actively engaged in it, and in conclusion, as an illustration of continued activity on the lines of the work already described, mention may be made of a piece of apparatus now being developed for use in tractor testing. This apparatus is intended to record in the field drawbar horsepower and percentage wheel slip on a base of drawbar pull. If successful, it will considerably shorten the time required to obtain these performance curves and, apart from use on N.I.A.E. testing, it may very well find an application in commercial development work. The tractor test recorder is an example of one direction in which this line of work may be expected particularly to proceed. At first, because of the heavy demand for tests, the immediate object was to provide as quickly as possible equipment to enable a good standard of testing to be achieved. Now, when some of the short-term problems have been solved, future work is likely to be concerned to an increasing extent with the development of apparatus designed especially to reduce to a minimum both the time spent in the field and the labour of evaluating results.

U.S. Naval Architects' Summer Meeting

THE summer meeting of the U.S. Society of Naval Architects and Marine Engineers will be held on September 5th to 15th in Washington, D.C., in conjunction with the sixth International Conference of Ship Tank Superintendents, which is jointly sponsored by the Society and the American Towing Tank Conference. Delegates from a number of foreign countries will be attending the meetings as guests of the Society.

The papers to the U.S. Society of Naval Architects and Marine Engineers will be read on September 6th and 7th, while the nine technical papers to be presented at the Conference of Ship Tank Superintendents will be given during September 10th to 14th and will include:—"The Linearised Theory of Wave Resistance for Displacement Ships in Steady and Accelerated Motion," by Professor J. K. Lunde, of the Model Testing Tank, Trondheim, Norway; "Potential Theory of Wave Resistance of Ships," by Dr. Rene Guilloton, of France; "Self-Propulsion Tests with Small Models," by Allan B. Murray, Edward V. Lewis and B. V. Korvin-Kroukovsky, of the Experimental Towing Tank, Stevens Institute of Technology, Hoboken, New Jersey; "Results to Date of Comparative Cavitation Tests of Propellers," by R. W. L. Gawn, of the Admiralty Experiment Works, Great Britain; "Economic Speed Trends," by Dr. E. V. Telfer, of Istanbul Teknik Universitesi, Turkey; "Manœuvring of Ships," by Captain R. Brard, Bassin D'Essais Des Carennes, France; "The Organisation of Merchant Shipbuilding Research in Great Britain," by Dr. S. Livingston Smith, of the British Shipbuilding Research Association, Great Britain; "Turbulence Stimulation on Ship Models," by Dr. J. F. Allan and Dr. G. Hughes, of the National Physical Laboratory, Great Britain; and "Skin Friction Resistance and the Effects of Surface Roughness," by Dr. F. H. Todd, of the David Taylor Basin, Washington, D.C.

ALUMINIUM ALLOY EXTRUSIONS.—A handbook detailing the properties of extrusions in Hiduminium has now been issued by High Duty Alloys, Ltd., Slough, Buckinghamshire. It is introduced by a description, with illustrations, of the extrusion process and with general notes on the design of sections. There follows the geometrical properties of some fourteen sections, which include the solid and hollow ellipse and circular segments, and there is also a fairly comprehensive list of beam formulæ with deflection and bending moment diagrams. The mechanical properties and moments about axis are then indexed according to sections for all the available sections, such as angles and channels, &c., tubes and miscellaneous extrusions.

Designers' Formulæ

By W. A. TUPLIN, D.Sc., M.I.Mech.E.*

IN the lecture room the student who asks for a "formula" at the end of a discourse on the application of mechanical principles to a design problem is rightly chided. In the education of engineers the object is to impart a grasp of fundamental principles applicable to a wide variety of subjects and it would be contrary to that aim to devote attention to numerous formulæ each of limited scope.

In practical design, however, the position is quite different. There the designer is presumed to have already acquired a reasonably wide range of technical knowledge and the need is to use it to the best advantage in coping with his daily problems. When dealing with repeated problems of the same general kind, appropriately devised formulæ are essential for speed and certainty. They minimise labour, tend to consistency and reduce the chance of serious error. So effective may they be that in many branches of machine design, recurring problems are solved reliably and efficiently by people with little technical insight into the theoretical background. In some cases, indeed, the designer's acquisition of all available knowledge on the subject would no more improve his work than would perusal of steam tables be a help to a locomotive driver.

To be above criticism, however, a working design formula must have been intelligently developed to meet the conditions to which it is applied in a sound compromise between convenience and accuracy. It must therefore have been devised by someone who has built experience in the particular class of problem on a foundation of sound knowledge of theoretical origins and practical results.

Not every design problem has been provided with a cut-and-dried solution. In some cases no such solution may be possible; in others no special effort may have been made to produce one by those who might be expected to do so. Possible reasons for the failure of experienced men to devise working formulæ are:—

(*a*) Inability to devise a satisfactory one.

(*b*) Inability to devise one that is 100 per cent correct in every possible case.

(*c*) Disinclination to admit that long experience in handling any one class of problem can be reduced to a formula.

(*d*) Reflection that there are more lucrative ways of using the fruit of experience than giving it away in working formulæ.

The development of simple design formulæ is usually possible (where it is possible at all) only to someone of long experience in the subject. Consciously or subconsciously he rejects the factors that he has found to have only a slight influence on the result and this is important in the interest of simplicity. The academic instinct is, of course, to call in as many factors as can possibly affect the matter but the resulting formula may be so complicated as to be unusable even where the available information provides numerical values for all the factors in it.

In many practical design problems, data essential for a rigorous solution are simply not available and a formula embodying an experienced man's assumed values for items of the missing information is likely to be more reliable than an apparently more refined formula in which the average user must insert his own estimates of unascertainable quantities.

So far as calculation is concerned, designers fall into three main classes:

(*A*) is content to employ a formula that has already had long use by someone else and indisposed to make any critical examination of its origin or limitations.; is touchingly faithful to "the way we've always done it," no matter how serious the shortcomings of that way may be shown to be.

(*B*) is scientifically trained and at first imbued with the academic aversion from working formulæ.

(*C*) is possessed of theoretical knowledge, practical training, experience in design, ability to devise sound working approximations and conviction that they are necessary as a basis for sound and economical design.

An irrational attitude sometimes found in the class *A* designer, is the assumption that because a formula that he has used for years has not seriously let him down, no other formula can possibly be reliable, let alone superior. It is an attitude that might, for example, have opposed Whitworth's standardisation of eight threads per inch for a 1in bolt on the ground that some manufacturer had always secured excellent results from nine threads per inch and therefore that no other number was admissible.

Most design work of a repetitive character is in practice carried out by class *A*. Class *B*, scornful of "formulæ" consults the text-books, makes each design problem into a minor research investigation and after much time and labour produces designs that may not be sound or economical. After a few experiences of this character the discerning class *B* man begins to understand that there is something to be said for the methods of class *A*.

The class *C* man has graduated through classes *A* and *B*, and appreciates the viewpoints and limitations of both and understands the commercial and technical necessities of formulæ for design in industry. Class *C* is the normal source of reliable design formulæ.

The deviser of a working formula may happen to have written a text-book but (and this is what class *B* men have difficulty in recognising) text-books are not in general directly helpful in practical design because:—

(*a*) Text-book writers are usually more closely associated with the theoretical aspects of the subject than with the practical ones and may not fully appreciate the value of short, clear-cut design methods.

(*b*) By the time the author has done all the essential work for a text-book, collecting information from all sources, making it into an ordered sequence, presenting all the alternatives, preparing diagrams, unifying nomenclature, chasing inconsistencies, glossing weaknesses, disarming criticisms and so on, he has neither inclination nor energy for extending his work to a field where bold approximation is required and rigour is often a handicap.

(*c*) To show after hundreds of pages of background that the essential solutions of design problems can be compressed into a hundred lines, is something like anti-climax.

Close examination of the theoretical ramifications of a design problem is apt to exclude from the designer's mind such matters as the practical importance of using standard tools and components. Although the advantage of the widest possible application of standard details is not open to serious dispute, those responsible are often reluctant to effect it. It is clearly less trouble for a draughtsman to draw details to suit their surroundings in the design without considering existing standards, than it is for him to fashion the whole design so as to use standards to the maximum extent. Some mentalities also discern as much indignity in using commonplace standards in their work as they do in using public transport vehicles instead of smaller ones of traditionally higher snob-value, and so sacrifice economy for puerile pride. Others derive, from association with a problem for which they can see no solution based on standard components, a feeling of unctuous self-importance rather than the more appropriate one of inadequate ingenuity. The sound designer, however, neither scorns to use standards where it is easy nor shrinks from doing so where it is hard.

Gear design is a branch of mechanical engineering for which the development of reliable design-formulæ is most important, first because toothed gearing has such wide application; secondly, because the apparently imperishable oldest formulæ are unnecessarily restrictive for gears cut by generating processes; and, thirdly, because the nature of the theoretical side of the subject offers class *B* designers unusually strong inducements to plunge into unnecessary complication and expense. It is, moreover, a subject in which text-books have tended to obscure the possibilities of combining simplicity and economy in design. The basic reason for this is that whilst the earliest machine-cut gears were produced by form-cutters on the cycloidal system, normal practice has long been to use the extraordinarily flexible combination of the generating principle and the involute tooth form. On this basis a single cutter can produce teeth of usable shape in a blank of any diameter exceeding four times the pitch and is not limited to any one number of teeth in any one size of blank.

Such flexibility in gear design is quite impossible on the original form-cutting basis or on any system but that of the involute. No one could have imagined such freedom when form-cutting was the rule but the design methods developed for that restricted field still persist and exert a severe and totally unnecessary restriction on gear design long after form-cutting has been superseded. Successions of class *A* designers have perpetuated the old ways and many of them look upon use of "non-standard" gear diameters as a most dangerous piece of sharp practice. In other words the flexibility of the involute system is nullified by the inflexibility of a mental attitude.

It is the tradition—from cycloidal days—that every gear has a definite "pitch circle" that makes it so difficult for many designers to understand that involute gears may be designed, manufactured and operated without any thought of that hamstringing concept. In fact, an involute gear chooses its own kinematic pitch circle to suit the needs of the moment; to attempt to tie it down to one particular pitch diameter is to create an artificial hindrance to economical design.

Some of the theoretical principles that were reasonably employed in connection with the earliest gearing systems have been carried over to generated gears and have cast their design into an unnecessarily rigid mould. A brief examination of the principle of generation of spur or helical gears will illustrate the point.

Given a gear generating machine (say,

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a hobbing machine), a hob made in accordance with British Standard tooth-form and a cylindrical gear blank, one can convert the blank into an involute spur gear without drawing or calculating tooth shapes and without considering such things as pitch circles or involute functions.

The setting-up operation of the machine involves merely fitting "index change gears" corresponding to any selected number of teeth and fitting and mounting the hob so that the tooth helix at the mid-depth of a cutting tooth lies approximately parallel to the axis of the blank. The cutting operation comprises rotation of blank and hob at uniform speeds, sinking the hob to full tooth depth into the blank and then traversing the hob across the face width of the blank.

There is some restriction on the number of teeth that the machine can successfully cut in the blank. For a given hob-speed, the rotational speed of the blank is inversely proportional to the number of teeth for which the machine is set up. If the peripheral speed of the blank is much greater or much less than the "screw-motion" speed of the hob-teeth parallel to the axis of the hob they will clearly mill away the outer layers of the blank and the result will be, not a gear, but a somewhat roughly finished cylinder.

If the surface speed of the blank approximates to the screw-motion speed of the hob teeth, then teeth (equal in number to that for which the machine is set up) will be cut in the blank. At the circle at which the circumferential speed of the blank is the same as the screw-motion speed of the hob, the thickness of the generated teeth tends to be equal to the space between the hob-teeth at the coaxial cylinder that touches that circle. Elsewhere the generated tooth thickness is less than the hob-tooth space-width at the corresponding cylinder. Extreme types of teeth are shown in the illustration.

The tooth *T*22 is thin at the root because there the circumferential speed of the blank was much less than the screw-motion speed of the hob teeth. At about half-depth the speed difference is less, but it is more than counterbalanced by the difference in the width of the hob tooth and so the generated tooth *T*22 is thinner near mid-depth than anywhere else.

The tooth marked *T*13 is sharp-crested at a diameter less than the original outside diameter of the blank because the outer circumferential speed of the blank was much greater than the screw-motion speed of the hob teeth.

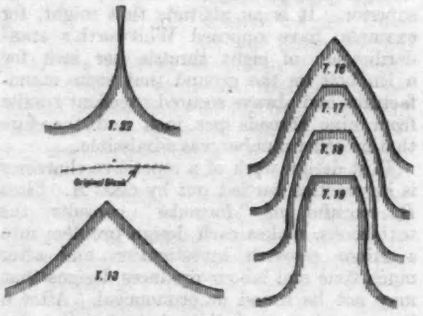
Between the extremes of *T*22 and *T*13 lie more obviously usable gear teeth, such as those shown to the right of the illustration. All these are possible products of the same hob and the same blank, with the machine set up for different numbers of teeth, and all the useful parts of the tooth profiles are of involute form, with the same normal base-pitch as the hob. All such gears could mesh correctly with all others generated by the same hob.

The obvious practical question is "For a given blank and a given hob, to what range must the number of teeth be confined in order that the tooth form shall be neither undercut nor sharp-crested?"

The tyro, who knows no more than the old lists of "tooth parts," would say that there is no range at all and not even one value unless the blank diameter happens to be just right. The text-book gives no direct answer to the question, although it does contain data from which an answer may be developed. The rigorous reply is to prescribe a number of algebraic expressions, in which tentative tooth-numbers may be tried to find whether the resulting quantities satisfy certain criteria. The useful answer is a pair of simple algebraic expressions that define upper and lower limits of tooth-number when figures for the blank diameter and the normal pitch of the hob are inserted in them. Such limits lie between the rigorously determined limits but yet embrace a useful working range unless the pitch of the hob teeth exceeds about a quarter of the blank diameter, in which case no useful range exists.

It could be demonstrated by actual trial that involute gears generated by a common cutter with different numbers of teeth in blanks of a common diameter, will actually mesh correctly with each other or with a common mate. This would be quite impossible with form-cut teeth, even on the involute system, and to explain the geometrical basis of this flexibility involves consideration of "pitch diameters of generation," "pitch diameters of engagement," and pressure angles of generation and of engagement.

It is certain, however, that given a number of blanks on which to experiment, an investigator completely ignorant of gear



Produced in a blank of diameter equal to $20/\pi$ times the pitch of the cutter when a B.S. cutter is used to generate 22, 13, and 16, 17, 18 or 19 spur gear teeth

TOOTH-FORMS

geometry could determine an empirical formula for the useful range of tooth-number for any ratio of blank-diameter to pitch of hob. Similarly, a draughtsman could devise such a formula after drawing out tooth-shapes, whilst a gear technician can do the same thing by calculation alone.

The converse formula, showing what range of blank diameter is permissible in conjunction with a particular hob set to cut a particular number of teeth, is equally easily determinable and is equally useful to the designer.

Armed with such formulæ and without difficulty or labour, the designer may make good use of the flexibility of the involute system. He can get, in fact, more flexibility than he needs, so that he is saved some embarrassment by arbitrarily restricting the blank diameter of the pinion of a pair to one particular algebraic function of the pitch of the cutter and the number of teeth in the pinion, but allowing the blank diameter of the wheel to have any value between two algebraic functions of the pitch of the cutter and number of wheel-teeth. In other words, there is one "formula" for pinion blank diameter and two limiting "formulæ" for wheel blank diameter.

The gear-cutting machine is set up for the number of teeth to be cut in the particular blank concerned and (in the case of helical gears) for an axial pitch common to the two gears.

The standard generating cutter is sunk into each blank to the standard full depth, plus a small amount dependent on the backlash required in the mating gears and on the departure of their centre-distance from the conventional one. The nominal working centre-distance of the pair of gears is half the sum of the blank diameters less the standard working depth.

The range of wheel-blank diameter enables any specified centre-distance to be accommodated for gears generated by any cutter. With the possible exceptions of very rare cases, in which the gears must have some high velocity ratio with no tolerance at all, the range of wheel diameters permits any centre-distance to be accommodated with gears of acceptable velocity ratio generated by some standard cutter.

Some old information on gear design has led many uncritical designers to believe that a gear with a specified number of teeth, cut by a specified cutter with a specified axial pitch, must have a particular tip diameter. Of these the class *A* man may be disinclined, or afraid, to accept the statement that any practical gear design problem can be solved without assuming the use of non-standard cutters. He would sooner specify a non-standard cutter (he does not pay for it) than abandon eighteenth-century procedure for what many smatterers even yet regard as a most suspicious piece of chicanery. The class *B* man, on the other hand, is likely to ask whether tooth-action with "non-standard" diameters is satisfactory in theory or practice. As in most engineering matters, practice has led theory in this respect. Blanks have been cut, by design or by accident, with "wrong" numbers of teeth and yet the resulting gears have meshed properly with their mates at the velocity-ratio corresponding to the numbers of teeth. This having been demonstrated, geometers were not long in proving that it must be so, but that the working pressure angle is not necessarily the nominal one and that the maximum sliding velocity between the teeth may not be so low as in corresponding gears of conventional design. The methods of determining the values of these quantities are described in gearing text-books and the class *B* designer may well be tempted (usefully so far as the mental exercise is concerned) to study the detailed results of varying the number of teeth cut in a blank of given size. Such labour does not help in any specific design, however, as the ground has been thoroughly covered long ago. The exact value of the working pressure angle is of no practical importance and in no ordinary gear drive is any practical benefit secured by specially minimising the maximum sliding velocity. There may be some academic satisfaction in calculating the details of geometric form and kinematic action of gears cut in a specified way, but after fifty years of gear generation it would be strange if no simple and reliable design rules were conceivable for the vast majority of purposes. It can reasonably be expected that those who have had repeatedly to design gears have developed some routine for doing so and that is actually the case. Not all these routines are equally sound or useful, but the best possible is still a routine that does not depend on the unreliable promptings of instinct or dimly remembered experience. Gear design is no art, except in the generous Patent Office sense, which (no doubt) admits that there are arts of potato-frying, dish-washing, road-sweeping and so on. But even art in the artistic sense builds on a limited number of elements, such as twelve tones or twenty-six letters, and so mechanical design, even of the highest order, can be reasonably restrained to the

use of standard components and dimensions instead of non-standard ones within their range. In particular, a gear designer is wrongly so called if his specification calls unnecessarily for non-standard manufacturing equipment.

A class *B* designer who has read some of the voluminous literature on gearing, who has roamed in the geometry and kinematics of tooth-forms, who has learned what endless varieties are possible in the involute system alone and who has tried to follow the arguments for the theoretical advantages of this, that and the other system of selecting tooth proportions, no doubt finds it difficult to believe that for 99 per cent of gearing applications the unadorned British Standard system is technically as good as any other and in British practice is far better than any other, simply because it is the standard. That is, however, the fact, and it is not too much to say that, save for the one freakish case in a hundred, a gear design that demands the use of non-standard tools and equipment is a bad one.

This is not brought out in gearing text-books, which, for the sake of exhaustiveness, usually make reference to the large number of gearing systems that have had some following in the past and offer fatal temptation to the class *B* designer to depart from the current standards. This merely emphasises that the usual text-book is not a text on gear design; Buckingham, in the preface to his "Analytical Mechanics of Gears," says so specifically of that particular work. The class *B* man's tendency to pick up a text-book as a preliminary to designing a pair of gears is following a hard road into trouble. As well might a farmer enter a completely equipped engineering works and proceed to manufacture a farm tractor for himself. The result would be neither quick nor good.

Time and again cases are encountered of unsatisfactory operation of gears designed on some long out-moded system or upon the well-meant inspiration of some immature designer and produced with the unnecessary expense of non-standard cutters. The usual cause of this class of occurrence is a class *B* designer's skimming of some old text-book, and a common stumbling block is the "stub" tooth. On the face of it a short, stubby tooth is stronger than a long, flexible one but in actual fact that is not the case. This is past history and if it could be conveyed to all who essay gear design that the British Standard tooth-form, appropriately used, offers the minimum danger from common pitfalls, much time and money would be saved.

There would be less difficulty in ensuring the universal use of British Standard tooth-form if designers in general had a more vivid idea than they have at present of the expense and nuisance involved in non-standard cutters. In a small shop, where design, buying, manufacture and selling may all come closely under the eye of one man, the advantage of minimising stocks of cutters is obvious to that man. In a large organisation, where estimating, design, tooling, production, inspection and purchasing are separated functions, the essential relations between them are not appreciated by every individual concerned with them. Because of the artificial conditions produced in the engineering industry since about 1937, by preparation, conduct and aftermath of war, there are many designers who lack practical experience and appreciation of cost in design and manufacture. To such men the loss involved in drawing up a design that demands non-standard tools means little. The man who orders the tooling equipment may not be competent to question whether the design could not have been based on the use of standard tools. The supplier of the tools raises no question because he can justifiably charge more for non-standard tools than for standard ones. There is an obvious need for an overriding instruction that none but standard tools shall be used, but this can be effective only where matters of dispute can be referred to an arbiter of sufficient experience and grasp of the subject to see through attempts to claim exception where it is not technically justified. Apart from such control, it is often possible for a man to save himself half an hour's work at the cost of £25 worth of material and labour in some other department.

Many gear drawings reveal the slightness of the acquaintance of the draughtsman and his supervisor with rational gear technology or even with established engineering principles. Specification of gear tip diameter (measured at interrupted surfaces that do not fit anything) to four places of decimals and spiral angles (not sensitive to ten minutes in setting up the machine) to fractions of a second of arc suggest failure to associate the lines on the drawing with necessary or possible workshop procedure.

Allowable Loading

Regular use of formulæ does tend to inhibit the desirable mental connection between figures on paper and the physical quantities that they represent. Calculated geometrical dimensions are sometimes presented to purposeless degrees of refinement but it may at least be said that they have been developed from a rigorous basis. There is no excuse, however, for writing down meticulously precise figures for allowable loading on gear teeth or other stressed parts or for asserting that a pair of gears are unsuitable for a certain duty just because their calculated load capacity is 5 per cent below the nominal load. Among the things that have not been realised by anyone who makes such an error are:—

(1) That no load capacity formula is certain to err by less than 10 per cent.

(2) That every load capacity formula refers tacitly or otherwise to some particular number of cycles of load variation.

To the 10 per cent specified for (1) must be added, in most cases, at least 10 per cent uncertainty about the value of the applied load. There is no certainty about any practical load-capacity formula and when it is stated (for example) that a certain gear may carry a tooth load of 1000 lb, the real meaning is that there is only a 1 in 100 chance that the gear will have failed after making (say) 10 million revolutions under that load. If the applied load is 1500 lb the 1 in 100 chance applies to failure after perhaps 4 million revolutions. For certain failure after (say) 100,000 revolutions a load of 10,000 lb might have to be imposed.

In few presentations of load capacity formulæ has this general position been made clear and many designers apply them as if they had Euclidean rigour. Some, however, mostly of class *B* are critical enough to point out that the British Standard load capacity formulæ (for example) ignore factors that certainly influence the actual capacity. The formulæ can be criticised on rational grounds and yet, within the limitations of the wide field of experience on which they were based, they do give satisfactory results. By application of a "speed factor" they reduce the allowable tooth load on a gear as its number of revolutions per minute increases. This variation is in the right direction but its nature is difficult to justify, although the resulting error may not be serious within normal limits of the speed of gears.

The British Standard formulæ are applicable to a very wide range of size and speed of gears. If attention is confined to a narrow range, somewhat simpler formulæ become possible and this has been done for automobile gears. After examination of nominal stresses on successfully used gears, the allowable stress in the material of any gear was made to depend on the calculated steepest gradient up which the engine could drive the fully laden vehicle with that gear in use. The steeper the gradient the less frequently will it be necessary to apply such loading in a vehicle in normal service and therefore the higher is the permissible stress under that loading.

The nineteenth-century aim in engineering design was to use working stresses below the fatigue limit, so that components might be expected to last for ever. It was never possible to work on this lavish basis in aircraft design and because of the same need to save weight, it has ceased to be so in the automobile field.

The class *B* designer who does not realise this is sometimes disposed to question the apparent inconsistency in British Standard load capacity formulæ between automobile gears and others. Actually there would be no inconsistency in departing even further from the general method in dealing with automobile gears for heavy road vehicles. In that class of service the heaviest gear loading occurs when climbing gradients, the running resistance even at the highest possible speed on the level being relatively low. Consequently the relation between magnitude and duration of the heavy loads on the gears is determined by what fractions of the total mileage the vehicle may be expected to run up the gradients corresponding to its various gearbox speeds. Because the transmission load on a steep gradient is determined almost entirely by gravity, other resistances being negligibly small, it may be calculated from total weight, gradient and wheel diameter; the figure for maximum engine torque is used only to determine for what range of gradient each gearbox speed will be used.

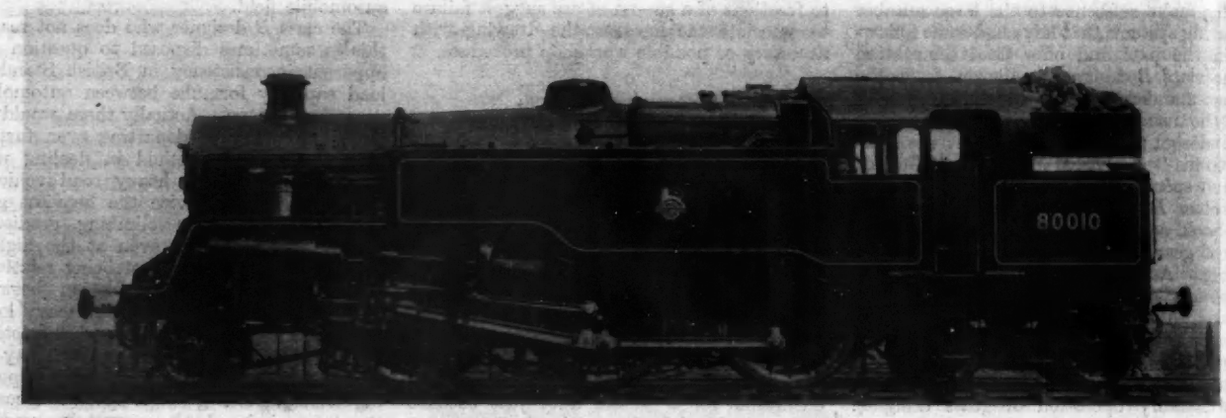
This method of treatment does not differ in essence from the normal one of working on the torque developable by the prime mover. It arises from the realisation that there are two gears in a pair and that it may be easier to estimate the probable loading by considering what is happening at the output side of the gearbox rather than the other. Artifices of this sort are not usually mentioned in text books, presumably because they are so obvious that any engineer may be expected to resort to them. That is not so in practice, and the average designer's reliance on formulæ is partly responsible for occasional failures to perceive where basic principles would serve him better.

In an article published in about 1898 on the education of engineers, a case was mentioned in which the father of a seeker for a job asked the prospective employer what standard of mathematics he demanded in young, technically-trained engineers. The reply was: "Well, I like them to be able to do rule of three, but I don't often find that they can." Fifty years later we may have progressed a little from this state. Nowadays one would like every young mechanical engineer to know Newton's Laws of Motion sufficiently well to be able to use them with confidence in design, but the time is not yet.

Standard 2-6-4 Tank Locomotives

IN the photograph reproduced on this page can be seen the first of the new standard Class "4," 2–6–4 tank locomotives for British Railways, which was recently completed at the Brighton works of the Southern Region. Of the fifty-four locomotives of this type to be built under the 1951 programme, forty-four will be constructed at the Brighton works and the remainder at the Derby works of the London Midland Region.

As with the other standard engines, these locomotives have been designed and built under the direction of Mr. R. A. Riddles, the member for mechanical and electrical engineering of the Railway Executive. Brighton has been the parent office for the design, whilst certain of the sections have been designed at Swindon, Derby and Doncaster. The work of designing this new locomotive has been carried out at Brighton concurrently with work on the designs of the Class "4," 4–6–0, tender locomotive. The two types are of similar size and operating capabilities from the point of view of power output, and many of their details are interchangeable. Following the standard practice nearly all the fittings on the two types are common with those of the other standard locomotives.



STANDARD MIXED TRAFFIC TANK LOCOMOTIVE

The new tank engine is intended for short-distance suburban and cross-country train working and shorter distance freight train haulage. It will have almost universal availability over the main and secondary lines of the country, and its leading dimensions are as follows :—

Cylinders, diameter and stroke	18in × 28in
Wheels, coupled, diameter	5ft 8in
Wheels, pony truck and bogie diameter	3ft
Wheelbase, coupled	15ft 4in
Wheelbase, total	36ft 10in
Heating surface :	
Tubes, square feet	1223
Firebox, square feet	143
Total evaporative area, square feet ...	1366
Superheater, square feet	246
Grate area, square feet	26·7
Boiler pressure, per square inch	225 lb
Tractive effort	25,100 lb
Adhesion factor	4·73
Weight of engine in working order ...	86 tons 13 cwt

The boiler is of the same general design as the L.M. Region class "4" 2–6–4 tank engines, except that the staying has been redesigned to accommodate the boiler pressure, which has been increased from 200 lb to 225 lb per square inch. There are twenty-one large flue tubes, 5¼in diameter outside, 7 S.W.G. thick, and 157 small tubes, 1¾in diameter outside and 12 S.W.G. thick. The length between tube plates is 12ft 3in. The Belpaire firebox has outside dimensions at the bottom of 8ft 6in in length and 4ft 0½in in width.

In the rocking grate there are seven rocking sections each fitted with fourteen renewable fire-bar units. The front four and rear three sections of the grate can be rocked from the footplate independently, the arrangement of operating gear being such that the full travel of the lever may be used for fire dropping when the locomotive is standing over a pit, or a limited movement used when in road service for disturbing the fire to eliminate ash and break up clinker. A self-emptying ashpan has two flap doors in the lower section, operated from ground level. Front and rear damper doors are provided and are controlled by screw gear and handwheels mounted in the cab.

A vertical grid regulator located in the dome has the operating shaft placed transversely across the boiler and mounted in a stuffing box on the second barrel ring. An external rod is employed for the connection to the regulator handle in the cab.

Boiler feed water is delivered through two "top feed" clack valves, placed at approximately 30 deg. on either side of the vertical centre line of the front barrel ring, and passes over two inclined trays which deflect it round the inside of the barrel clear of the tube bank. A steam manifold fitted on the firebox top outside the cab incorporates separate shut-off valves to each steam supply pipe in addition to the main shut-off valve, which is fitted with a handwheel inside the cab. Two safety valves are located on the firebox top in front of the manifold, and a blowdown valve is fitted at the front of the firebox throat plate immediately above the foundation ring, for manual operation from ground level.

The cylindrical smokebox is supported by a fabricated saddle, and has a self-cleaning arrangement which consists of plates and a wire mesh grid arranged to prevent accumulation of ash and the emission of large particles of unburnt fuel. The blast pipe has a plain circular cap 4¾in diameter, which also contains the four Cardew type blower nozzles.

The engine frames, of 1½in thick steel plate, are braced by horizontal and vertical stretchers, the majority of which are fabricated. The axlebox guides are steel castings riveted to the frame plates and are provided with manganese steel liners on the wearing faces. Lugs integral with the guides are provided for the pin-jointed cross stays which maintain the correct relation between the frames.

The boiler is carried in the frames by rigid attachment between the smokebox and the saddle, and by a downward extension at each back corner of the firebox foundation ring resting on shoes supported by a frame cross stretcher, to permit longitudinal expansion.

Plain bearing axleboxes are fitted to all wheels, and the coupled wheel axleboxes are steel castings, with pressed-in white-metalled horseshoe brasses. Sliding underkeeps of ample oil capacity, with pad lubrication supplied by oil from a mechanical lubricator, are fitted and the guide wearing faces are provided with manganese steel liners welded to the axlebox and lubricated by grease.

The two 18in diameter by 28in stroke cast iron cylinders are placed outside the frames, and the 10in diameter piston valves are operated by Walschaerts' valve gear. The valve gear gives a maximum travel in 75 per cent full forward gear of $6^{27}/_{64}$in with a steam lap of 1¼in and a lead of ¼in. The box type piston heads are fitted with two rings with a bronze spring-loaded slipper on the underside to minimise the piston head and cylinder barrel wear. The crosshead is guided by the two-bar slide bars with upper and lower bars.

Lubrication of the cylinders and piston valves is by atomised oil supplied from a mechanical lubricator. The valve gear is mainly lubricated by grease and plain bearing joints are used, except for the return crank rod big end, which has a self-aligning ball bearing.

The coupled wheels are 5ft 8in diameter and the tyres have the lip fastening adopted for all British Railways standard locomotives. Forty per cent of the reciprocating masses are balanced, the weights in the wheels being built up with steel plates to house the lead.

Steam sanding is provided to the leading and driving coupled wheels for the forward direction and to the driving wheels also for reverse running.

The bogie has laminated springs for compensating beams and side bolsters. Side play control is effected by double helical springs. On the pony truck helical bearing springs in two nests are employed, each nest consisting of two springs, one within the other, arranged on either side of each axlebox. The load is transmitted to the axlebox by means of a yoke and shoe. Side play control is through double helical springs, and helical springs are also employed for the side movement retarding gear fitted fore and aft of the truck centre on the axle centre line.

Steam brakes provided on the engine can be operated by means of a separate steam brake valve or in conjunction with the vacuum brake. The coupled wheels only are braked by means of a single block on each wheel.

Water pick-up gear is provided for both forward and backward running on engines which will operate in the London Midland Region only, but provision is made for the fitting of the gear on all engines, if required.

The cab, is dimensioned to suit the smaller of the British Railways loading gauges, but follows the lay-out of all the standard locomotives.

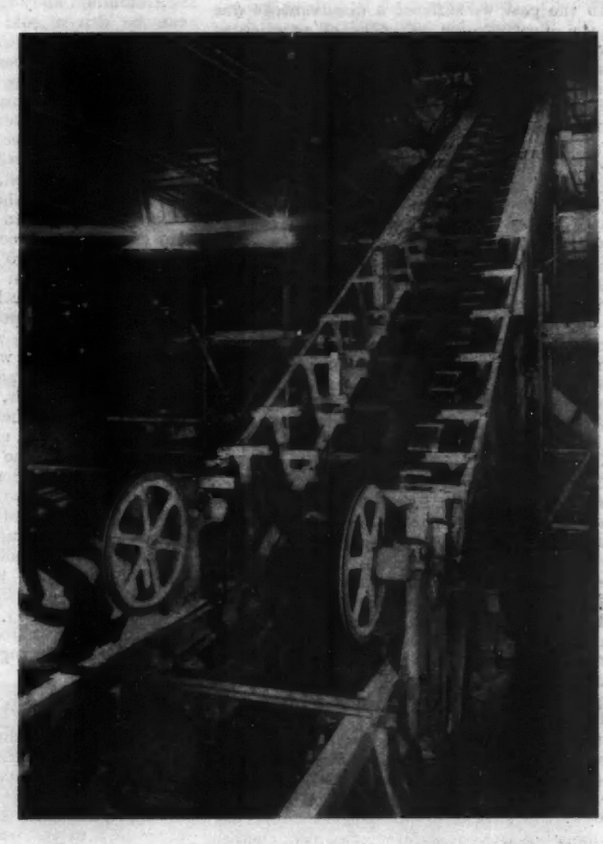
The tanks and bunker are of welded construction throughout. Each tank has curved sides and a pressed U-shaped bottom, and is supported at the forward end on the outside slide bar bracket and at the rear end on a frame bracket. The curved form was adopted primarily for both tanks and bunker to suit loading gauge restrictions, but has also been made to conform with the profile of British Railways standard coaching stock. The tanks have a water capacity of 2000 gallons and the bunker a coal capacity of 3½ tons.

The Escalator in the Dome of Discovery

ONE of the interesting installations in the Dome of Discovery at the South Bank Exhibition is the heavy-duty public escalator, which runs between the ground and upper gallery floor levels of the building. In this unit the 70ft long inclined section is 35ft high at its uppermost end and it is completely unsupported between the upper and lower ends. It is believed to be the longest unsupported escalator span yet built and in its design special provisions had to be made in the drive to offset the effects of possible deflection of the supporting truss under load.

This escalator was built and installed to the designs of J. and E. Hall, Ltd., of Dartford, by the Standard Steel Company, Ltd., of Croydon. It can be seen both in the course of erection and when completed in the photographs we reproduce on this page. It is what is termed a 4ft unit and each step is intended to carry two adults in comfort. With a speed of 100ft per minute, the escalator has a rated capacity of 8000 passengers per hour, and during its tests carried 9000 per hour.

COMPLETED ESCALATOR



ESCALATOR UNDER CONSTRUCTION

The escalator structure is of Warren truss girder design and, in addition to supporting its own and the driving unit weights, is arranged to carry a moving load of up to 9½ tons when fully loaded. The unit is driven by a 40 h.p. squirrel-cage motor through a worm reduction unit which is coupled to the main escalator shaft by a pinion and helical gear wheel keyed on the shaft. Owing to the fact that the escalator is always started under "no load" conditions, the starting torque required is low. The driving gear is situated in a motor room at the top or gallery level and access to this room is through a manhole in the gallery floor.

It will be appreciated that any deflection in the main structure would be likely to cause the main drive to move out of alignment and it is to avoid this risk that the helical gear wheel of the drive is linked with a pinion in such a way that it is free to take up normal deflection without affecting the drive. Sprocket wheels at each end of the main drive shaft carry the main chains to which the escalator steps are attached. These chains are designed for a breaking strain of 120,000 lb and have links of "jack-knife" design to ensure that stretch is kept to a minimum. As each of the chains is 193ft long, if cumulative stretch in the links were not provided for in their design, frequent adjustment of the stretch compensating gear would be necessary.

The steps are coupled to the chain links through two main rollers, each 7½in diameter, and each step also has two trailing rollers 5½in diameter. These rollers run in angle steel tracks supported by the main structure on the incline, and in curved cast iron sections at the top and bottom ends of the escalator. The guide tracks for the rollers are accurately machined and aligned to provide smooth running of the stairs. Each of the rollers has a machined steel hub, which runs on ball bearings and is tyred with "Fabroil" to give a long working life combined with silence in operation.

One of the problems involved in designing this kind of escalator, which is built to suit vertical heights of up to 80ft, is the arrangement at the uppermost end, where the steps change from the incline to the horizontal, and where the load on the rollers is greatly increased. This load increase is due to the action of the rollers running round a curve whilst the chain partially travels in a chord of the arc. Depending upon the number of passengers being carried, this movement could produce resultant loads on the rollers likely to lead to failure of their tyres. To prevent this, even with a full, continuous load, a roller relieving device is fitted at the upper end of the escalator structure. The relieving device consists of two endless chains fitted with 4½in diameter rollers so arranged that each step is supported through the region of increased loading by three steel rollers, and the load is taken completely from the normal step support rollers.

The lowermost end of the escalator unit is floating and is held in position by means of the step chains, which pass over the bottom end-sprockets, and by springs which are connected to an anti-stretching device. The handrails are in the form of endless bands, which run over sheaves chain-driven at both ends from the main driving sprockets. At the top the rails are double-lapped round a stretcher sheave, through which their tension can be adjusted. To reduce handrail slip to a minimum, the canvas backing is moulded with a vee-shaped tongue to increase the drive friction. Any adjustment which is made to the main chains at the lower end of the escalator does not affect the handrail drive, which is at all times synchronised with the step speed.

The normal range of safety devices is fitted to the escalator mechanism. An overspeed governor coupled to the main drive unit is arranged to cut off current supplies and apply a brake, in the event of the escalator overspeeding, by a pre-determined amount. This governor also incorporates an anti-reversing device and should its driving chain break the brakes are automatically applied. Mercury switches are mounted on the bottom end tensioning equipment and come into effect to stop the escalator in the event of one or both of the main step chains stretching unduly or breaking.

CONTAINERS FOR BRITISH RAILWAYS.—British Railways have ordered 1000 4-ton steel containers of a new design for conveying ground limestone, dolomite, fluorspar, alumina, cement, and similar substances. This design, which is the result of experiments made with a prototype, is in the form of a lidded box divided into two equal compartments, which can be discharged simultaneously or separately through bottom doors, the doors opening by gravity on release of a catch. The lid is designed to operate with the minimum of headroom when open. The container is waterproof and is provided with cleats on the sides so that sheets may be fixed during unloading to keep down dust. A contract for the construction of the containers has been placed with Cravens Railway Carriage and Wagon Company, Ltd., of Sheffield.

Aluminium in Structural Engineering*

By Colonel W. C. DEVEREUX, C.B.E., F.R.Ae.S.†

THE great problem in the structural use of aluminium alloys is the cost of material, which volume for volume is about two and a half times that of steel. In order to overcome this disadvantage, the engineer must resort to accurate and skilful design to provide a suitable structure using the minimum amount of material. He is greatly assisted in this by the versatility of the extrusion process, and by the high corrosion resistance of aluminium, which enable him to use sections exactly designed to meet the conditions of service and to use very thin sections without risk of deterioration due to atmospheric attack. Thus, latticed girders are preferred to prismatic beams, and we have turned away from structural steel practice towards aircraft methods of stressing, which, however, require a very high standard of stress analysis and design ability.

In the past we suffered a disadvantage due to the incorporation in codes of practice of standards of deflection based on steel structural practice. Such standards did not really represent essential hard and fast limits; rather were they arbitrary figures derived from deflections usually experienced in well-designed steel structures. The new standards issued recently allow much more reasonable deflections in aluminium structures.

All these things, however, although they make designing in aluminium very interesting and offer great scope for ingenuity, also increase the cost of design and fabrication, and so there comes a point at which further saving in material is secured only at a disproportionate cost in design and fabrication. So seldom does one get the opportunity of mass production that the number of different sections it is practical to use is limited, for although the cost of extrusion dies is low, it is obviously impractical to make tools for special sections for each job or to lay in large stocks of a vast variety of sections; so we have to compromise.

The most important difference between design technique for light alloy and that for steel is the effect of the lower modulus of elasticity because of its bearing upon problems of deflection and the design of compression members. It is much more necessary for the designer to check the actual deflection of a light alloy member than is the case with steel members, where a section which is strong enough from the bending point of view is usually within the limits of the deflection requirements. This is not always the case with light alloy members, particularly when the span to depth ratio is fairly high. The elastic modulus has, of course, a very important effect upon the strength of compression members, and for this reason the cross section of a light alloy strut should be designed so that the member possesses greater flexural rigidity without using more material. For these reasons we originally evolved a system of construction in which the compression members were double-channel sections battened together, giving an extremely stiff member for the amount of material used.

More recently, under pressure of increasing costs of material and fabrication, we have been coming round to the view, which has already been expounded by Marsh,[1] that the advantages of the extrusion process can perhaps be exploited more economically by using simple bulb angles instead of double channels. By this technique, we have made designs representing only one-fifth the weight of equivalent steel structures. The cost per pound of the extruded bulb angles is usually more than 10 per cent cheaper than that of channels, "top hats," &c.—a saving which almost outweighs any increase in weight over the more elaborate types of construction. The amount of fabrication is equal to that in corresponding steel structures, and is considerably easier to execute and consequently cheaper than in steel.

* Abstracts from a lecture delivered at the Aluminium Congress, Zurich, May 9, 1951.

† Managing director, Almin, Ltd.

RIVETING

The most expensive part of structural engineering, apart from the cost of material, is joining the various members together. Much of the assembly of aluminium buildings and structures immediately after the war, especially of the "aluminium house," was done in aircraft factories, and naturally used aircraft methods, including the use of tubular or "pop" rivets of small diameter. This practice has much to commend it for the mass assembly of light structures by unskilled labour. However, it was soon found that as structures became larger, "pop" riveting began to show serious limitations. Moreover, using largely unskilled labour, as we have to do, once we depart from series production, the question of where to drill each hole becomes a question for skilled supervisors. Thus, for a special design it is necessary to mark out on the job the position of each rivet so that, quite apart from other technical and economic considerations, it becomes an urgent matter to reduce the number of rivets by increasing their diameter.

Aluminium alloy rivets of up to ¾in diameter can be driven cold by large static squeeze riveters, but they are not very flexible machines. Semi-portable squeeze riveters, of the kind used on the assembly of the ribs for the Dome of Discovery, for example, are capable of closing rivets of ¾in diameter and are far more flexible in use and can be employed for most shop work. They are not, however, readily adapted for site work which, in most cases, calls for pneumatic riveting hammers, which in practice means we are limited to rivets of not more than ¾in diameter. In consequence, we have been forced in the past to utilise steel bolts for most of the site joints in large structures, which is undesirable as they have to be made to close tolerances and specially protected against rusting.

A great deal of work has been undertaken recently to devise means of driving large rivets with portable tools, and it is interesting to note that one of the most promising solutions has been developed simultaneously in the U.K. and in Canada—the recessed point developed by Military Engineering Experimental Establishment[2] and the annular point developed by Aluminium Laboratories.[3] The amount of material in such points is less than that available in a conventional point, but it is claimed to be quite adequate for the purpose. In fact, Sir Donald Bailey goes so far as to question whether a head is necessary at all, since, he says, a cold driven rivet does not, in any case, hold the plates tightly together as does a hot driven rivet.

WELDING

There is no doubt that for some purposes riveted aluminium structures are at an economic disadvantage compared with welded steel structures. Progress in the welding of aluminium structural alloys has been disappointingly slow in the past, but the signs are that we are now on the threshold of important advances in this technique. There is a parallel here with the case of the laboratory corrosion tests I shall deal with later. Sir Donald Bailey has referred to this recently with reference to the important experimental work carried out by himself and his colleagues at the Ministry of Supply's Military Engineering Experimental Establishment. He finds that the high conductivity and specific heat of aluminium have several beneficial results in welding. The tendency to hot cracking is reduced, the properties are improved as the cooling rate approaches that of solution treatment, and the depth of heat-affected parent metal is localised. In a massive arc-welded structure of AW.10 alloy, he found little softening beyond ¾in and virtually none at ¼in from the boundary of a ¾in fillet, welded with one run of a 0·232in diameter electrode at 300A.

Sir Donald concludes that the mass of the member being welded has an important bearing on the behaviour and properties of the weld. This fact has led to many discrepancies between the behaviour to be expected from laboratory results on small test pieces, and actual results on full-scale structures. R. A. Foulkes[4] has given an interesting illustration of the economies in weight which may be expected to result from welding. A cross girder in high-tensile steel weighed 650 lb, an equivalent girder of riveted aluminium alloy construction weighed 420 lb, while a similar aluminium alloy girder assembled by arc welding weighed only 308 lb. This work, together with reports of results achieved in welding heavy sections with the new consumable-electrode shielded arc-welding machines recently developed in America, encourage great hopes of immediate practical progress in this field.

CORROSION RESISTANCE

When I gave a paper on this subject in London two years ago I had to bring in the subject of corrosion with great caution because I had found by experience that many engineers were still afraid of the corrosion of aluminium alloys.

Actually, the corrosion resistance of aluminium and its alloys is among their most important properties. They compare favourably with most other structural materials generally accepted and esteemed for durability. Why is it then that the atmospheric corrosion resistance of aluminium is not more fully recognised and stressed? I believe this to be due mainly to the following causes:—First, aluminium was known to have a high affinity for oxygen, and it is difficult to reduce from the oxidised state; hence, it was regarded by those who first produced it as being easily oxidised or corroded. There is still some tendency to regard aluminium as a relatively easily corrodible metal for this reason, although it should hardly be necessary to point out that it is the form and character of the oxide film which primarily determine the resistance of a metal to oxidation, and that aluminium shares with chromium the ability to produce a highly protective oxide film which prevents subsequent attack.

There has been a tendency to standardise on salt spray accelerated corrosion testing, assessing the corrosion behaviour of aluminium, by exposing specimens for a few days, weeks, or months, and by assuming that the amount of corrosion occurring in, say, ten years will be twenty times that occurring in six months. This gives a completely misleading picture, since, when aluminium is first exposed to corroding conditions, appreciable corrosion takes place almost immediately, and naturally this is disturbing to engineers and others who are used to dealing with metals that corrode, at a steady rate.

The tendency for the corrosion rate to decrease with time has been carefully studied by Champion,[5] who has produced evidence that the rate of corrosion penetration is independent of the thickness of the specimen and he has shown that, after a short period, the corrosion rate decreases with time according to an exponential law. He concludes that this will enable the ultimate limit of corrosion in infinite time to be assessed. He goes so far as to suggest that aluminium alloys should last indefinitely and support the loads for which they are designed under the worst natural atmospheric exposure conditions if they are not less than 0·11in thick.

Arising from Champion's conclusions that, provided specimens are withdrawn at suitable intervals, a precise knowledge of the form of corrosion/time curves will allow extrapolation and results to be obtained in a relatively short time, I initiated with the Fulmer Research Institute a series of atmospheric corrosion tests on structural aluminium alloys in which we are interested. These tests have now been in progress for nearly two years and in most of the sites, corrosion after the first year has been too small to draw any conclusions on the rate of corrosion/time curve. The results of two years' exposure at the most aggressive site (Sheffield) have just become available for AW.10 alloy. Although these tests are still a long way from proving that Champion's theory is right, they do show that the results so far obtained lend some support to his views.

A number of incidental conclusions of interest have already arisen from this work. Fully heat-treated AW.15 has been shown in salt

spray tests to be susceptible to stress corrosion in sheet form, but not in the extruded form. This has been due to the fact that the corrosion has tended to separate out along planes parallel to the surface of the original extrusion following planes of inhomogeneity arising from the original extrusion. This applied both in laboratory salt spray tests and in atmospheric exposure tests. The sites chosen for this experimental work have included exposure both to marine and tidal atmospheres and complete immersion in both sea water and fresh water. Even in these sites the rate of corrosion has been less than on specimens exposed at Sheffield and has been very much less than in the laboratory salt spray test.

It has been noted, both in this work and in other current investigations, that the corrosion of aluminium and its alloys can be accelerated if wet or moist corrosion products are allowed to accumulate on the surface. We have noted, for example, that in specimens exposed at Sheffield there is more attack in positions where moisture has been allowed to collect and on the underside of specimens despite the fact that the exposed surface of the specimen was stressed in tension, whereas the underside was in compression. In the normal laboratory salt spray test, moist corrosion products remain on the specimens and attack is, therefore, more rapid than in specimens exposed in the sea, or in the atmosphere just above sea level, since in these cases corrosion products are periodically removed by the action of wind, rain and tide. It follows that, in designing aluminium structures, care must be taken to ensure that static water should not be allowed to remain continuously in contact with aluminium and its alloys. Because of the interest which the preliminary results in this investigation has aroused, we have arranged with the Fulmer Research Institute to continue this work on a larger scale.

Choice of Material

I have mentioned previously that in addition to our attempts to standardise the sections we employ, we have, in the past, standardised the alloys we use in our structure and we have in practice limited our construction, as far as possible, to one type of alloy, partly because we find it most economical to do so, and partly because, at the present stage in development, many consulting engineers, local authorities and architects have been somewhat prejudiced against the use of aluminium alloys because of the wide range of alloys available and the misunderstandings and confusion which can arise as a result.

The alloy we have chosen is BS.STA 7/AW.10 B—an alloy of the well-known aluminium-magnesium silicide type, similar to the Swiss Anticorodal, whose composition and properties are shown in the table. This alloy

BS./STA 7, AW. 10 B

Nominal chemical composition :	
Silicon, per cent	1·0
Manganese, per cent	0·7
Magnesium, per cent	0·8
Mechanical properties :	
0·1 per cent proof stress, tons per square inch...	15
Ultimate tensile stress, tons per square inch ...	18
Elongation, per cent on 2in	10

can be readily extruded in the thinnest practical sections ; it has a high resistance to corrosion in a wide range of atmospheres and it has strength comparable with the yield point of structural mild steel, which is important since this value is the criterion of ultimate failure for all compression members. At the present state of the art we consider that AW.10 offers the most favourable combination of properties in an aluminium alloy for structural purposes.

Events of the past few months may, however, force us to abandon the use of this alloy for some structural work, since it can only be made from virgin aluminium. We may, therefore, be forced to use instead an alloy made from secondary material containing an appreciable quantity of copper.

Conclusions

The way of the pioneer has never been an easy one, and as time goes on it becomes a more and more expensive one. I will not pretend that all the work we have done in new structural uses of aluminium has been successful from the financial point of view. I am certain, however, that with the experience gained on each type of structure where we have come out on the wrong side, we would compete competitively with other materials. I am quite convinced, however, and I hope others in the aluminium industry will agree, that in terms of long-range market development and of technical knowledge, these ventures are of great value to the industry as a whole.

In structural engineering, perhaps the oldest branch of engineering, the economic competition of traditional materials is most severe, and thus it is tempting, on the face of it, to go after the easier markets and to abandon the effort to capture the potentially vast, but enormously competitive, market for building materials. It has been stated in a recent survey that "in the span of one lifetime aluminium has grown to a point of usefulness which other commonly used metals took centuries to reach." Its production has increased twenty-five-fold in the past forty years. If expansion is to continue at anything like this rate, it is markets in capital equipment which will become increasingly important to the economy of the industry. To cast them aside for transient advantages without the most careful deliberation may set development back a decade or more.

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An Experimental Prestressed Concrete Bridge in California

The first prestressed concrete bridge to be constructed in the western part of the United States has now been completed. The structure is a pedestrian bridge across the Arroyo Seco flood channel in Los Angeles ; it incorporates an experimental method of anchoring the prestressing cables. The bridge, which is shown approaching completion in the accompanying illustration, consists essentially of two simply supported girders, each 113ft long, with a clear span of 110ft. The girders are 10in wide by 5ft 8in deep, have a 20in wide by 9in thick top flange, and weigh almost 50 tons each. These two girders support the 8ft wide pedestrian walkway and also serve as handrails. They were constructed at a site adjacent to the channel and were lifted by four large mobile cranes on to their permanent abutments after all prestressing operations had been completed. The concrete walkway was then cast in place between them. The girders are each reinforced with 125 high-tensile steel wires, each wire having a diameter of ¼in. The total tension which was applied in each girder was 715,000 lb. Initially the wires were cut to length and a button-head was peened on each end by a special machine. This button rests against a ¼in diameter washer, which, in turn, rests against the steel bearing plate or a stressing block, depending on the end of the girder involved. Tests indicated only negligible creep in this fastening even at 150 per cent of the design load. The wires were inserted in 26 gauge sheet metal casings to prevent bond with the concrete. The space around the wires was pressure grouted after tensioning through 1in diameter holes in the distribution plates. Five wires at a time were threaded through cast iron stressing blocks measuring 1in by 4in by 3½in. After the concrete had reached its full strength of 5000 lb per square inch, the stressing was undertaken by pulling on one block at a time. The formed wire channels in the two girders had a total volume of only about 2 cubic yards, but for the sake of speed and efficiency, rather powerful equipment was used for grouting them. The Halliburton Oil Well Cementing Company employed mobile units and accessories, such as are used in oil field operations. The cement and sand mixture was contained in the dry material unit and was delivered by screw feed to a cone-shaped hopper, where water was added. The mixture was then piped to the grout chamber and the pumping unit forced the mixed grout through the bearing block openings, thus quickly filling the spaces containing the wires from end to end of the girders. It is considered that the system employed for this bridge, whereby five wires at a time are tensioned, is considerably more productive than the Magnel method of stressing two wires simultaneously and, on the other hand, does not involve the more powerful equipment required by the Freyssinet method of stressing twelve wires at a time.

The bridge was designed for a live load of 55 lb per square foot on the pavement surface. The maximum working stress for the concrete was 1700 lb per square inch for concrete having a cylinder strength of 5000 lb per square inch. The maximum allowable initial stress in the high tensile wires was specified at 0·6 of the ultimate strength. The contractor decided to use a wire with an ultimate tensile strength of 220,000 lb per square inch and an allowable working stress of 132,000 lb per square inch. However, on account of the experimental nature of the project, the initial stress was limited to 120,000 lb per square inch. Allowances were made in the design for a total loss of initial prestress in the wire of 15 per cent, due to shrinkage creep, plastic flow and other causes. Seven Carlson strain gauges were cast in each girder ; three at mid-section and four at one of the quarter points. Readings were taken during the various stages of the work and will be studied by members of the staff of the Institute of Transportation and Traffic Engineering at the University of California. The prestressing of the bridge was carried out by the Prestressed Concrete Corporation, of Kansas City, Missouri ; the structure, as a whole, was a project of the California Division of Highways.

Arroyo Seco Channel Pedestrian Bridge

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LIVING CONDITIONS IN SUBMARINES

SINCE the discovery of the hull of the "Affray" near the Hurd deep, with her snort tube bent over and holed, the Admiralty has felt obliged to impose a temporary ban on the use of the snort pending further investigation into the cause of the disaster. This is an obvious precaution in the circumstance, though the Admiralty emphasises that there is no reason to suspect a collision. Assuming, however, that a surface ship or some large floating object hit the snort, it has been suggested in Parliament that the diesel engine would very quickly have created a vacuum by exhausting the air in the submarine when water instead of air came down the snort, thus incapacitating the crew while the submarine rapidly flooded. Cases have, indeed, occurred of a momentary vacuum while the engines were running at high speed with the submarine on the surface, due to the conning tower hatch closing when the vessel was rolling in a seaway. The engines then stopped on their own in a few seconds through lack of air, but the vacuum was fortunately soon destroyed by the additional air supply coming down the small ventilator—normally required for ventilating the battery while charging, but also used as an extra air supply for the crew when navigating on the surface. Even granting a collision, however, the creation of a vacuum in the "Affray" would have been very improbable as the engines when the snort is in use are run at a relatively slow speed and the air would not have been exhausted before the crew could have had time to stop them. Moreover, the snort tube has a valve where it passes through the hull which should automatically close with an inrush of a large volume of water. It seems more likely that the damage was done by the salvage ship H.M.S. "Reclaim" or one of the searching vessels dragging her moorings over the hull when anchored in the vicinity.

But whether or not the submarine sank because of damage to the snort, whether or not the tube requires strengthening or needs an extra safety valve, this Dutch invention, exploited by the Germans in the last years of the second world war, has come to stay—at any rate, until the genuine submarine, driven by turbine engines using peroxide of hydrogen and now building in the United States, has been tried out and proved successful. For it not only enables a submarine permanently to navigate submerged at a speed of 8 or 9 knots (except when enemy ships are in the vicinity), but also does away with the need for coming to the surface at night to charge batteries. From 1943 onwards in the last war, sudden and rapid attacks were made by our ships and aircraft from escort carriers on U-boats detected by radar on the surface and the Germans simply had to find an answer. The answer was the snort. Fitted with this apparatus, the U-boats dived on leaving harbour and remained submerged until their return, cross fixes from German wireless stations giving them their position when required. But a prolonged period of eight weeks or even longer in a submarine submerged has a very harmful effect on the crew. A submarine, it must be realised, is to all intents and purposes an elongated cigar-shaped steel cylinder, painted a glaring white inside the hull, with electric lights accentuating the glare on the eyes; fuel, water and compressed air pipes and various kinds of machinery are everywhere, and sleeping bunks fill up every inch of spare space between torpedo tubes and other equipment. With the submarine submerged permanently throughout the duration of the patrol, officers and men have no opportunity to escape from their cage by going up on the bridge, one or two at a time, for a glimpse of the sky and a breath of the fresh, cool night air. From captured German documents describing weight tests on members of the crew, it seems that a loss of weight of about 20 lb, accompanied by a marked deterioration in efficiency, was not uncommon at the end of a long patrol. By the end of the seventh week, the crew had become irritable and quarrelsome to the extent of prejudicing discipline. The monotony of their environment caused despondency, manual skill deteriorated noticeably and restful sleep became difficult.

A great deal of research work has been carried out since the war in United States medical research laboratories in an endeavour to improve this psychologically harmful atmosphere, and in 1949 an advisory committee was appointed to "make recommendations for designs, colours and materials for lessening eye strain, improving comfort and habitability, and promoting a more pleasant and congenial environment." The U.S. Submarine "Cutlass" was selected for the investigations and experiments, and a description has since been published of the alterations made in the interior of the vessel as the result of the committee's recommendations. After considering some fifty different shades of colour, the committee finally decided on three different shades of grey paint for the interior, green-grey, yellow-grey and medium grey. Alternate compartments are painted green-grey and yellow-grey, and machinery in medium grey. Torpedo tubes, ladders, clocks, fans, lockers and electronic equipment are painted the same colour as the compartment in which they are situated. Each compartment thus possesses a subtle difference from its neighbour, and while there is no appearance of drastic variation in colour—as one would experience when going from blue to red or red to green—the slight change from green-grey to yellow-grey registers on the subconscious mind and provides a constant feeling of variety. Strong colours such as blues or reds are too stimulating and fatiguing. The more inconspicuous the surfaces are in the interior of a submarine, the more do officers and men tend to forget their environment, that they are living, in fact, in a steel cylinder. Lights are an unavoidable necessity in every compartment in a submarine and the committee devoted much thought and effort to investigating this problem. Flesh-coloured lights were decided on for accommodation spaces to give a "healthy appearance" to the faces of the crew and the light fittings are duplicated to enable the position of the light bulbs to be changed—placed high up for a given period of time and then shifted to a lower position. Small low candle-power "spot lights" are provided for reading all important dials and gauges and the lighting is indirect throughout. Decks are covered with a brown linoleum tile and the table tops are of wood treated with plastic, similar to the tables found in any home. Seats are upholstered in plastic rattan and the bunk covers in the men's quarters are made of plastic and coloured green-grey or yellow-grey to blend with the scheme of painting. In the officers' quarters, curtains and bunk covers are maroon colour. The whole idea is, in fact, to simulate as far as possible the environment of the home—to try and achieve a sense of forgetfulness of one's surroundings. Up to date the results seem promising, but as far as is known the scheme has not yet had the rigorous test of an eight weeks' patrol with the submarine permanently submerged.

LOCOMOTIVE STANDARDISATION

IT is only to be expected that engineers making a particular study of locomotive operation will be keenly critical of the work of the new British standard types. The avowed principles of design have been set forth with admirable clarity by Mr. Riddles and members of his staff; the aim to produce,

for every grade of service, something that would be a synthesis of all that was best in the country has naturally aroused expectations, but already our own correspondence columns have included comparisons with former types which, taken at face value, are not flattering to the new engines. In making such comparisons, however interesting and revealing the figures may appear, account must be taken of the very difficult task that has been set to the designers of our own time. One correspondent has mentioned the Bowen-Cooke express engines of the London and North-Western Railway, built some forty years ago; they were express engines, and in their early days were confined to first-class express duties. On the other hand, all the new British standard engines so far built are mixed traffic units, designed for indiscriminate use in passenger and goods service alike. High annual mileages and low maintenance costs are now the twin yardsticks by which performance is measured, and in the case of smaller units, such as the Class "5" 4–6–0, complete pooling seems to be the aim, so that any engine in that category can be allocated to any job booked for a Class "5," whether that duty may be easy or severe, fast or slow. The locomotive controller, in the ideal condition, should not have to exercise any power of selection; it should be possible for engines to be rostered on the "first in, first out" principle, depending entirely upon the order in which individual units arrive on the shed roads concerned.

The London, Midland and Scottish Railway had gone some considerable way towards the achievement of this object so far as the robust Stanier Class "5" 4–6–0s were concerned. These engines have certainly won golden opinions from shed staff for the trouble-free service rendered all over the system, and in some respects this L.M.S. design has formed the basis of the new standard Class "5" 4–6–0. The principle of indiscriminate pooling certainly makes the clerical and administrative work of control much easier, but to us there appears another important factor that cannot be ignored. The fact that some severe turn of duty is just as liable to be worked by an engine that has run 100,000 miles since last overhaul, as by one in prime condition, means that the loading and schedule of the train concerned are limited to the capacity of a run-down engine. The programme of testing in hand at Rugby and Swindon includes the determination of the performance characteristics of run-down engines, and when such data is available we imagine that further intensive research will be carried out to try and narrow the gap between the performance of good and run-down engines. But however much the gap may be narrowed the principle of engine pooling inevitably means that the daily standard of performance, as represented by the public timetable, will be limited by the capacity of the worst. In earlier days the high standard of daily running set up by relatively small engines, as on the London and North-Western Railway, was due to the use of picked units on the heaviest duties, and a gradual tapering off as the mileage of individual machines mounted up. This practice is, of course, still followed in many parts of the country to-day, though the treatment meted out to the Stanier Class "5" 4–6–0s suggests the shape of things to come.

We wonder if this is not carrying standardisation and the common user principle too far. The Stanier Class "5" 4–6–0s, and their counterparts of Great Western, and London and North-Eastern design are, at their best, remarkably fast and powerful engines. The new Class "5" 4–6–0s should be still better. But such attributes will be largely denied to the public in the form of service improvements because schedules will have to be fixed to suit the engine that has knocked up 100,000 miles since last overhaul. With so many engines of this general utility kind available it does seem to us that some grading might be possible, where fast express passenger, or fast "fitted" goods duties are included in the rosters. When newly back from plant and reserved for crack workings such engines might not at first accumulate mileage as rapidly as in common user service; but we feel sure that any extra trouble involved would be amply repaid in the efficient working of important services, and there is no doubt whatever that the morale of engine crews would go up by leaps and bounds. For there is nothing more demoralising on a fast and arduous turn than to be saddled with an "old crock." No matter how well the designer has studied cab comfort, all such attentions will be in vain if a run-down engine is put on to a fast turn; minor defects become accentuated, and for the footplate men the journey is made in a pandemonium of racket and noise. On the other hand, with selected engines put on to the crack duties, a margin of power would be available to recover time lost by incidental slacks, and to maintain that punctuality which we regard as an obligation rather than a remote ideal.

Obituary

Dr. J. T. BATEY

It is with regret that we report the death, on July 23rd, of Dr. John T. Batey, at his son's home in Buckinghamshire, a few days before his eighty-ninth birthday. Dr. Batey, who has been in retirement for a number of years, was engaged in shipbuilding all his life, being mainly associated with the firm of R. and W. Hawthorn Leslie and Co., Ltd., on Tyneside. He was educated at the Royal Grammar School, Newcastle, and learned his shipbuilding with Andrew Leslie and Co., which was later to become R. and W. Hawthorn Leslie and Co. After the completion of his apprenticeship, Dr. Batey spent a few years extending his knowledge and then joined William Dobson and Co., Low Walker, as chief of the drawing-office, which post he occupied for ten years before returning to his old firm at Hebburn in 1901. His promotion was rapid and in 1907 he was appointed general manager and made a director of the company, eventually becoming managing director in 1921, a position which he continued to fill until his retirement some fourteen years ago. Dr. Batey was a past-president and fellow of the North-East Coast Institution of Engineers and Shipbuilders, which he joined in 1885, one year after its founding, and a vice-president of the Institution of Naval Architects, of which he had been a member since 1899. Besides taking an active part in the work of the technical institutions, Dr. Batey served on a number of committees, including Lloyd's Register Technical Committee and the Advisory Committee of the Froude National Tank.

W. LITTLEJOHN PHILIP

Mr. William Littlejohn Philip was actively associated with the business of Spencer (Melksham), Ltd., Melksham, Wiltshire, for over sixty years, and his death, which occurred at Bournemouth, on July 20th, in his eighty-ninth year, will be deeply regretted. Mr. Philip was born in Scotland in 1863, and was educated privately in Aberdeen. He served an apprenticeship with William McKinnon and Co., engineers, Aberdeen, and at the age of twenty-three was appointed works manager of Spencer and Co., at Melksham, Wiltshire. After eight years in that position, Mr. Philip became managing director of the company, and was subsequently elected chairman, from which office he retired in 1946. Apart from a short period in which he served as general manager of the Mirrlees Watson Company, Ltd., Glasgow, the whole of Mr. Littlejohn Philip's long and distinguished engineering career was spent with Spencer (Melksham), Ltd. He was responsible for the design and construction of many grain and coal-handling plants, both in this country and overseas, and, in addition, during the first world war, was closely concerned with the application of hydraulic power in the operation of machine tools. For his war services, Mr. Philip was awarded the O.B.E. in 1919. Mr. Philip was elected a member of the Institution of Mechanical Engineers in 1893 and for a number of years served on the committee of the Institution's Benevolent Fund.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

DISTRICT HEATING AT PIMLICO

Sir,—In your issue dated July 27th you describe the Pimlico district heating scheme as "said to be the first public heat supply in the country to make use of combined thermal electric generation."

May I respectfully point out that this distinction should be accorded to the Collingwood Estate scheme in Bethnal Green?

Early in 1947 my company approached the London County Council with the object of co-operating with them in the supply of heat for space and domestic water, and the scheme has been in full and completely satisfactory operation since November, 1949. Not only does this scheme fulfil all the textbook requirements of a thermal electric station, but also has the added significance of being an example of the co-operation of private and public enterprise, for it is along these lines that greater, and earlier, savings in the national resources will be possible.

G. Thornton Smith, Works Manager
Mann, Crossman and Paulin, Ltd.
Albion Brewery, Whitechapel Road,
London, July 27th.

PRESENT-DAY LOCOMOTIVE WORKING IN GREAT BRITAIN

Sir,—In considering that there is an error in the figures which I quoted (The Engineer, June 1st), I think Mr. Semmens is working on an incorrect basis. He states: "... the greatest thermal efficiency is only produced at one point, and this will correspond with the lowest coal consumption" (The Engineer, June 29th).

May I point out that, for a given train, the

coal consumption is a minimum when the pounds per mile, not the pounds per horse-power-hour, is a minimum. Generally speaking, the minimum coal consumption and the maximum thermal efficiency do not occur at the same speed.

This point is shown in Fig. 30 of the paper "Locomotive Testing on British Railways," where it can be seen that with the L.M.R. Class "2," 2-6-0 and 340 tons (of freight vehicles), the maximum efficiency on the level occurs at about 40 m.p.h., and the minimum coal consumption at about 35 m.p.h. No corresponding figures are given for the Class "5" 4-6-0, but it would seem that the figures which I quoted are not incompatible with each other.

I would suggest that if coal economies are obtainable from alterations to train speeds, a greater gain is likely to come from the speeding up of freight traffic than from alterations in passenger train timing, which, it seems, might be in the unpopular direction of lower speeds. Unfortunately, of course, freight train speeds can only be increased when the braking power is sufficient.

M. G. SMITH

Bath, July 23rd.

Literature

Modern Railway Motive Power. By BRIAN REED. London: Temple Press, Ltd., Bowling Green Lane, E.C.1. Price 8s. 6d.

THE object of this work is not to provide a book on the subject of locomotive design, nor does it pretend to describe in detail modern locomotives as found on the world's railways to-day. The author's main purpose has been to give a survey of modern practice and, in doing so, to indicate the present trend in the design of steam, diesel, gas turbine and electric locomotives. An attempt has therefore been made to cover a great deal of ground in a comparatively short space of 163 pages, which include illustrations.

The book is divided into sixteen chapters, of which chapters 3 to 13 inclusive are given up to steam motive power entirely. The first two chapters discuss motive power types and fundamentals and some locomotive limitations, respectively. Both these chapters serve the useful purpose of directing attention to the fundamentals underlying the problems appertaining to the provision of railway motive power, and are, moreover, well written. The author is an acknowledged writer on motive power matters, perhaps more especially those concerning diesel-electric locomotives and other forms of traction where the main source of power is the oil engine. A series of articles entitled "The Railway Oil Engine," which appeared in THE ENGINEER early in 1945, contributed by the author of this book, will be remembered.

The opening few sentences of the first chapter present what is certainly outspoken comment and, if agreement is found with the opinions expressed, "an extraordinary situation presents itself" without question. We are told that "In regard to steam power there has been no more than negligible progress during the past decade, and the position is worse than it was in 1939." "High-standard locomotive designs, excellent performance, keen and intelligent driving, and fast schedules are no longer keeping locomotive and traffic staffs on their mettle." "On the contrary," it is stated, "over a large part of the world steam locomotive design and operation has altered to suit the general attitude of labour—organised and individual—the serious materials situation, and the lack in the higher management positions of that authority commensurate with responsibility that is essential to the performance of any function."

This quotation paints a picture in anything but attractive colours and, if accepted, we must make up our minds to resign ourselves to the very mediocre rail services now in vogue.

Beyond the foregoing remarks in this chapter, the student will find an instructive graph showing pull-speed characteristics of typical high-capacity steam, diesel and electric locomotives. The following chapters, 3 and 4, deal with modern steam types and steam motive power; in the former there are tables giving particulars of modern locomotive boilers.

Chapter 5 is entitled "Compound Propulsion." The author's remarks on this well-worn subject are well worth notice. In theory at least all steam locomotives for main line heavy duties should be compounds, operated by enginemen trained to work them. To throw compounds on one side because the men cannot work them is pure nonsense and is not an acceptable excuse.

The boiler and firebox receive attention in Chapter 6. Stress is laid on the importance of grate area and the size of the firebox. In regard to the latter, volume is considered as being necessary for proper combustion. This may be agreed, providing the volume is in the right place—that is, immediately above the grate; in other words, if we have a deep firebox. Combustion space beyond the arch is of questionable utility and, in the last analysis, there is no doubt that grate area is the ruling factor. Tube heating surface is said to be a "secondary matter." Is this really true? If the performance of the boiler as a whole is examined, it will be found that, as the weight of the mixed gases liberated per square foot of grate area advances, the proportion of the total heat transfer that is transferred by the firebox heating surfaces diminishes, while that transferred across the tubular heating surfaces increases. Herein lies the importance of the tubular heating surfaces and the reason for the high steaming capacity of the locomotive boiler.

Another point given attention is the free gas area through the boiler. Granted that this is a factor requiring proper consideration, it is at the same time impossible to be too dogmatic as to the proper relationship between the gas passage area and the grate surface. In practice, this ratio varies within wide limits without detracting materially from boiler performance.

The chapters dealing with valves and valve gear, the chassis and driving gear, the locomotive as a vehicle, and testing methods will be read with interest and profit.

The subject of roller bearings, now becoming increasingly common, is given attention. Mention is made of the increased stiffness of the axle, due to the inner race and the bearing as a whole, resulting in fractures of axles inside the wheel seats when roller bearings were first applied to coupled axles in America. This trouble was overcome by machining stress-relief grooves in the inner face of the wheel boss, and for the same purpose it may be pointed out that the new standard engines being built for British Railways, fitted with roller bearings, have shallow, semi-circular grooves formed in the axles between the axleboxes and wheel seats to provide the required elasticity.

Diesel traction, discussed in Chapter 15, gives some interesting information, supported by graphs illustrating the efficiency of transmission systems for diesel vehicles and their speed-tractive effort curves; and, finally, the concluding chapter describes the gas turbine locomotive, and includes a general drawing of the Metropolitan-Vickers locomotive for British Railways.

The closing pages include a bibliography and a good index of contents. It is a readable and instructive book for engineering students who desire some knowedge of the present trend in railway motive power practice.

SHORT NOTICES

A.S.T.M. Standards on Copper and Copper Alloys. By the American Society for Testing Materials, U.S.A.: 1916, Race Street, Philadelphia, 3, Pa. Price 4·35 dollars paper cover, 5 dollars cloth cover.—More than a hundred current A.S.T.M. standards appertaining to copper and copper-base alloy products have been assembled in this volume, which is mainly for the benefit of the industrial user. It contains twenty materials specifications on copper, copper alloys and copper-covered steel wire, rods and bars and stranded conductors for electrical purposes. Thirteen specifications deal with various non-ferrous metals, such as slab zinc, nickel, silicon copper and lead. A further sixty-three specifications relate to copper and copper alloy products in the form of plate, sheet, strip, wire, rods, bars and shapes, pipe and tubes, sand and die castings, arc welding electrodes and brazing solders. On the subject of inspection practice the book contains ten test methods covering expansion, resistivity, tension, micrographic, hardness and grain size evaluations. Finally, a recommended practice is outlined for the preparation of tension test specimens for copper-base alloy sand castings.

Production Engineering for Higher National Certificate: Vol. I, Machine Tools. By R. Dent, A.M.I.Mech.E. London: English Universities Press, Ltd., St. Paul's House, Warwick Square, E.C.4. Price 18s.—This volume of the publisher's technical college series is primarily intended to cover the work in the syllabus for Higher National Certificate courses in production engineering. It also covers ground useful for those taking City and Guilds courses in machine shop engineering and other courses. The first chapter deals with operation planning on various types of machines with calculation of cutting times, the estimation of handling times and how to make allowances for tool setting, regrinding, &c. Then, after dealing with feeds and speeds, separate chapters are devoted to the principal machine tools and their operation and design. Each subject is well illustrated with photographs, diagrams and drawings, and at the end of every chapter a number of exercises are provided on the particular subject covered.

BOOKS RECEIVED

Industrial Electrical Plant Maintenance. By E. G. Anness. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 27s. 6d.

Architects', Builders' and Civil Engineers' Reference Book. Edited by E. Molloy. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 63s.

Principles and Practice of Radar. Third edition. By H. E. Penrose and R. S. H. Boulding. London: George Newnes, Ltd., Tower House, Southampton Street, W.C.2. Price 42s.

Quartz Vibrators and Their Applications. By P. Vigoureux and C. F. Booth. London: His Majesty's Stationery Office, York House, Kingsway, London, W.C.2. Price 30s.

Elementary Theory and Design of Flexural Members. By Jamison Vawter and James G. Clarke. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 32s.

Prüfungs und Übungsaufgaben aus der Mechanik des Punktes und des Starren Körpers. By von Karl Federhofer. Vienna: Springer-Verlag in Wien 1, Mölkerbastei 5. Price 16s. 6d.

Time Bases (Scanning Generators), Their Design and Development. Second edition. By O. S. Puckle. London: Chapman and Hall, Ltd., 37, Essex Street, W.C.2. Price 30s.

Motor Vessel "Norfolk Ferry"

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

THE train ferry is by no means an innovation, for as far back as 1860 the North British Railway shipped wagons across the Firth of Forth from Granton to Burntisland and across the Tay at Dundee, the object being to save unloading and loading again, but with the opening of the two famous railway bridges the services became unnecessary. However, the idea took definite shape abroad and in 1872 a Danish train ferry was put into operation across the Little Belt, and a similar practice was adopted across the Straits of Messina, in Scandinavian waters and over the Great American lakes. There was no further development in this country for many years, the proposed Channel tunnel being more to the fore, and, indeed, work on this was begun, but stopped for military reasons.

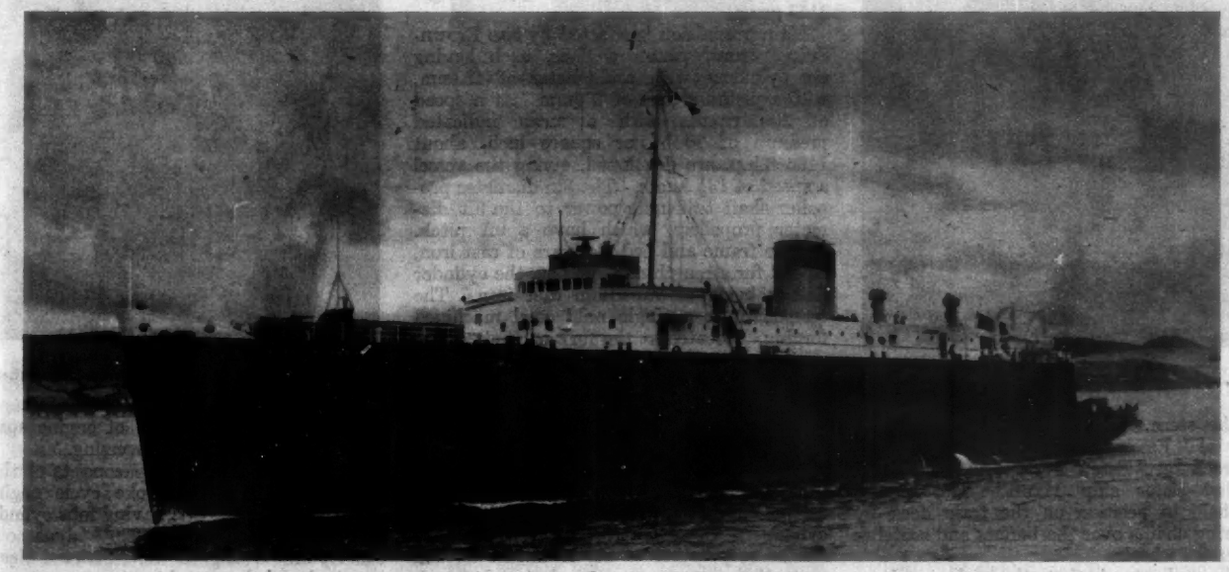
In the Great War the urgent necessity for more rapid transport without unnecessary handling became increasingly acute, and one of the most carefully guarded secrets was the construction of the Richborough railway terminal in Kent, and the building of three train ferries for operating between that port and Dunkirk and also between Southampton and Dieppe. The work involved was considerable, so much so that when it was possible fully to describe it seven articles in THE ENGINEER of 1919 were devoted to the subject. So successfully was the secret kept that the enemy remained in the dark all the time.

Three vessels were built for the service, two on the Tyne by Armstrong, Whitworth and Co., and the third on the Clyde by the Fairfield Shipbuilding and Engineering Company Ltd., and sailings began early in 1917. At the time of the Armistice over a million and a quarter tons had been transshipped. The principal dimensions of these vessels were :— Length between perpendiculars, 350ft; breadth moulded, 58ft 6in; depth, 17ft 3in; tonnage, 2672. They had a mean draught of 9ft 6in. They were driven by two sets of triple-expansion engines with cylinders of 18in, 29in and 47in diameter and a stroke of 27in. Steam was supplied by four single-ended Scotch boilers, 12ft 6in diameter and 11ft 9in long, working at a pressure of 180 lb per square inch, with Howden's forced draught and oil firing, which gave the ships a speed of 12 knots. Each vessel had four railway tracks and was capable of taking fifty-four 10-ton trucks.

After the war these ferries were taken over by a private company, the Great Eastern Train Ferry Company, Ltd., and in 1924 a service was initiated between Harwich and Zeebrugge, which ten years later was taken over by the railway. All the vessels did useful work during the second world war, but only one survived, No. 1; she was reconstructed by John Brown and Co. Ltd., in 1946, being renamed "Essex Ferry," and her appearance was considerably altered for she was given one large funnel, in place of the two narrow ones. In August, 1946, she resumed the sailings for the exclusive carriage of merchandise between Harwich and Zeebrugge, but with only one vessel in service it was very difficult to cater for the tonnage available, and it seemed to be imperative to have a new ship as soon as possible, so that next year a larger vessel was launched at the yard of John Brown and Co., Ltd., joining her sister at Harwich in Sep-

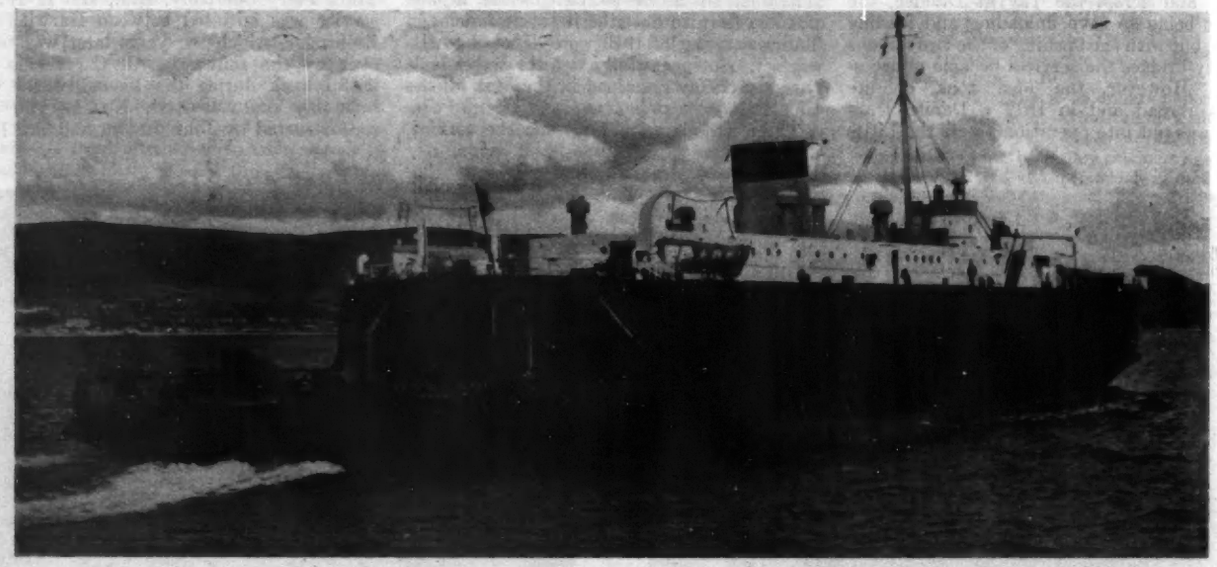
ORIGINAL TRAIN FERRY NO. 1.

"ESSEX FERRY" (NO. 1. AFTER RECONSTRUCTION)

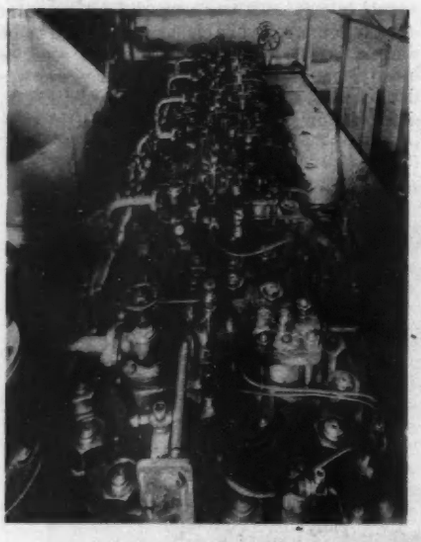


"NORFOLK FERRY" ON HER TRIALS

tember, 1947. "Suffolk Ferry" is 389·2ft long, 58·8ft broad, 15·5ft deep, and has a tonnage of 3134 gross. Unlike her sister, she is a motor vessel, being driven by two-stroke cycle, single-acting, oil engines with twelve cylinders, 18½in diameter by 27 9/16in stroke, which impart to her a speed of 13 knots. With these two ships it was possible to institute a daily service, and the ferry has proved useful in bringing back British locomotives which had been used on the Continent during the war, and also for conveying a large number of goods wagons built in England for the Continent. The number of wagons which can be carried must depend on the size of wagon, but on average between thirty-two and thirty-eight are taken on each sailing. These are carried on four sets of railway tracks, which converge into two at the stern. This is shown in the stern view of "Essex Ferry." The total length of track on "Essex Ferry" is 1108ft and on her sister ship 1126ft. The wagons are held in position on the train deck by securing chains over the buffers and scotches under the wheels.



STERN VIEW OF "NORFOLK FERRY" SHOWING COVERED-IN TRAIN DECK

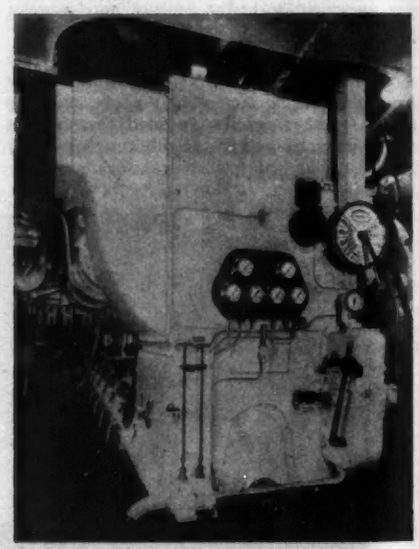


PORT MAIN CYLINDER HEADS

We understand that these ferries have become more popular since the war and in order to meet the public demand it became evident that a third vessel was needed, and on March 8, 1951, "Norfolk Ferry" was launched at Clydebank, being built by the same firm as "Suffolk Ferry"—John Brown and Co., Ltd.—and similar in many respects but modified as a result of experience gained, particularly as to her forward structure, but with a similar form below the water line. The upper deck, which extends for nearly the whole length of the vessel, serves as a cover for the train deck. As on the other ships, four lines of railway track are provided, and the deck has been constructed so that the heaviest modern locomotives could be carried, if necessary.

As will be seen from the illustrations, "Norfolk Ferry," when viewed from the bows, has the appearance of a modern cross-channel steamer, whereas the stern gives some idea of her specialised work. A train ferry can hardly hope to be a beautiful vessel, but it can be seen that she has at least some claims to good looks. Her principal dimensions are as follows:—Length, 397ft 6in (overall), 380ft (between perpendiculars); breadth, 61ft 6in (over fenders); depth, 34ft 9in (to upper deck); tonnage, 3157 gross.

Main propulsion is effected by two Brown-Sulzer trunk piston engines, each having six cylinders, with a diameter of 480mm, with a piston stroke of 700mm At a speed of 200 r.p.m., with a mean indicated pressure of 76 lb per square inch, about 1465 b.h.p. are developed, giving the vessel a speed of 13½ knots. The 8in diameter propeller shaft transmits power to the 9ft diameter propellers, which have a 9ft pitch. Engine frame and bed-plate are of cast iron, ribbed for strength and rigidity, the cylinder linings being of vanadium cast iron. The crankshaft is a single mild steel machined forging. Located at the forward ends of the engines are the scavenge air pumps, these being double-acting vertical reciprocating units, each having two pistons operating in tandem in two cylinders placed one above the other. The cylinders have a bore of 960mm and the piston stroke is 400mm, and these pumps discharge into receivers of rectangular section extending the full length of the power cylinders. Special care has been taken to ensure easy access to the crankcase as well as to the scavenge pump jacket and the air receiver. The fuel injection valves are cam operated, the camshaft being driven from the crankshaft through gearing located immediately aft of the engine cylinders. A flywheel is fitted at the aft end of the engine, ensuring a system free from any barred critical speeds, the turning gear being arranged to operate on the rim of this flywheel. The pistons are cooled by lubricating oil discharged to the crown by standpipes. The cylinder jackets and heads are cooled by the circulation of fresh water, but sea water can be circulated in an emergency. The engine control station which is located at the forward end of the engine, consists of a fuel regulating lever which is fitted with a small handwheel, operating a bevel gear transmission to a worm shaft, thus enabling there to be a fine control of engine speed. Another lever is used for reversing.



PORT MAIN ENGINE—CONTROL POSITION

The auxiliary machinery consists of three Davey Paxman four-stroke cycle engined generators, each engine having four cylinders and driving a 125kW, 220V dynamo at 600 r.p.m. Owing to the restricted size of terminal and the vessel having to assume an exact position for making the rail contact on

shore, a considerable amount of manœuvring is inevitable, and this in turn necessitates an adequate supply of compressed air for starting the main engines. This is provided by three Reavell two-stage air compressors, each capable of supplying 100 cubic feet of air per minute at a pressure of 450 lb per square inch, the compressors being driven by a 47 h.p. motor running at 600 r.p.m. Two large air receivers of 165 cubic feet capacity are located at the forward end of the engine-room. Steam for domestic and other purposes is supplied by a Cochran boiler of 4ft 9in diameter and a height of 11ft 9in, the evaporation being 100 lb per hour at a pressure of 100 lb per square inch. The necessary heat is obtained by means of an oil-burning plant of the Wallsend low-pressure type, with an electrically driven

APPROACH HOIST SHOWING WAGONS BEING SHUNTED ABOARD

blower. Two Weir reciprocating feed pumps are provided and a Weir air pump for the auxiliary condenser.

The forced lubrication system is catered for by three Drysdale "Vertoil" pumps of 53 tons per hour capacity, these pumps also being used for circulating the piston cooling system. The fresh water circulation in the cylinder jacket is ensured by two Drysdale upright pumps of 120 tons per hour capacity, while two similar pumps of 180 tons per hour capacity furnish sea water circulation for the various Serck coolers and auxiliary condensers. Two Drysdale "Centrex" pumps are supplied for bilge and ballast service, and another pump of the same type is for general service, the sanitary pump being of the upright design. Three De Laval centrifugal purifiers are provided, two exclusively for fuel and the third for lubricating oil, but arrangements have been made for this to be cross connected to the fuel system if desired. Each purifier is driven by a 1½ h.p. motor at 1450 r.p.m., which give a capacity of about 250 gallons per hour. A Victor oily water separator of 10 tons per hour capacity is located on the starboard side of the engine-room forward, and adjacent are two diesel oil transfer pumps of "Vertoil" type. Ventilation in the engine-room is ensured by four Thermotank torpedo fans driven by 3¾ h.p. motors, each supplying 10,000 cubic feet per minute. The engine-room is well laid out and conditions comfortable. It was noticeable that the main engines are well apart, but by an ingenious system of mirrors it is possible to see all the telegraphs from either engine.

Accommodation for officers and crew is found on the upper deck, which forms a cover to the train deck, and this accommodation is of a high order, and on the same deck there are six two-berth cabins for the use of passengers, these being much more commodious than those normally found on cross-channel steamers. A spacious and well-equipped dining saloon is near the passenger quarters. All three vessels on this service are equipped with modern navigation aids, including radar and decca, and it is rarely that voyages are interfered with as a result of bad weather.

On crossing to Zeebrugge on "Norfolk Ferry" it was noticeable that while in port the vibration from the generating set was very apparent, but when the main engines were working this vibration seemed damped and the running was smooth and comfortable. A good deal of time was lost both going and returning by having to negotiate the lock into the Bruges Ship Canal, off which the train ferry at Zeebrugge terminal is located, but work is in progress to construct a new terminal in the outer harbour, thus obviating the necessity for passing through the lock and reducing the passage time by at least two hours on the round trip. The delays are greatest in the summer, when the ferries are carrying perishable foodstuff, on account of the heavy traffic along the Belgian coast on the electric tramway which crosses the bridge at one end of the lock and the railway that uses the bridge at the other end. The accompanying illustration shows the approach hoist structure. The photograph reproduced was taken from the ship and shows wagons being shunted aboard.

Our thanks are due to British Railways and the various officials who readily gave help in the preparation of this article and afforded the opportunity of seeing "Norfolk Ferry" in normal operation.

First "Brabazon" Passenger Flights

FROM London Airport on Wednesday last we were able, upon the invitation of the Bristol Aeroplane Company, to experience a flight of some thirty minutes' duration in the "Brabazon I," Mark I, landplane. The "Brabazon" had previously visited London Airport on June 15, 1950, but it had not then the requisite category of airworthiness to carry non-fare-paying passengers. Its present certificate of airworthiness has been awarded as a result of 300 hours' test flying covering stability and control, oil and engine cooling, stalling, centre of gravity investigations and other essential tests. It has been possible also as a result of extensive oscillation and flutter investigations to remove the external mass balances from the rudder and elevator controls. This modification not only reduces the drag and improves the "feel" of the controls, but effects also a weight reduction equivalent to that of three passengers.

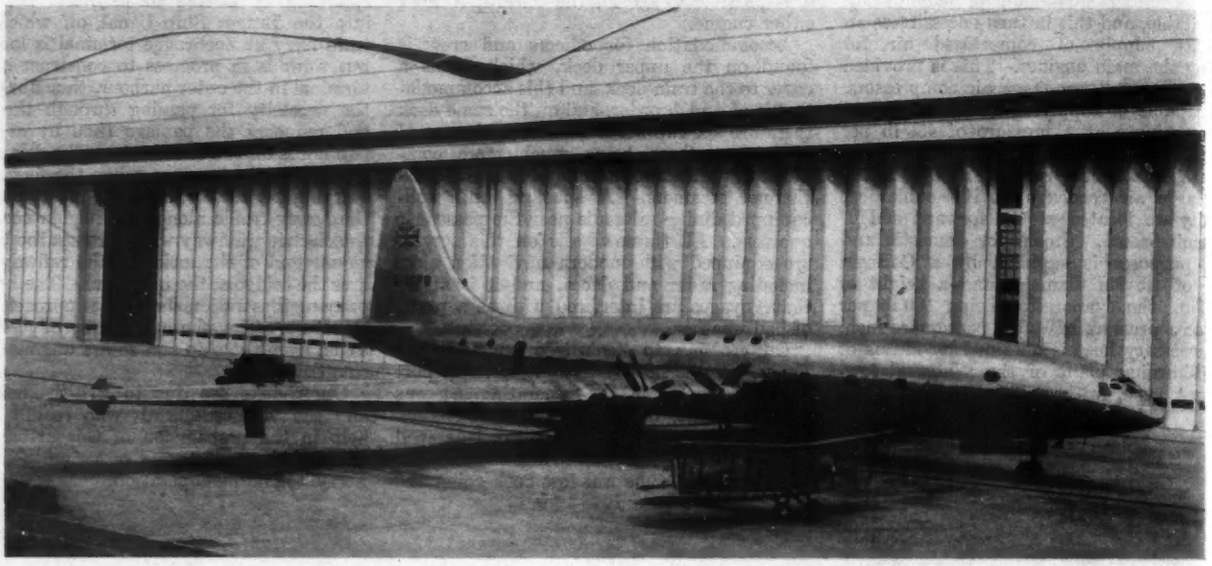
It will be recalled that the "Brabazon I" was designed on the recommendations of the Brabazon Committee in 1942 to meet the requirements for an airliner to maintain a non-stop service between London and New York, and on September 4, 1949, the Mark I aircraft first flew successfully at Filton Airport. The controversy which later surrounded this and similar projects has perhaps not yet been decisively resolved, although it has been stated that this particular version is not now to go into production. However, it is maintained that, from technical considerations, the "Brabazon" project has justified the confidences of both the designers and the Brabazon Committee.

Lord Brabazon himself was amongst the passengers included in the Parliamentary Scientific Party during the first flight, and in four subsequent trips were Ministry of Supply officials, press representatives, and guests of the company.

A CORNER OF THE PASSENGER SALOON

Although the construction and development of the "Brabazon" have from time to time been described in THE ENGINEER, it is perhaps worth while to recall a few details from a specification which bestows upon the "Brabazon" the distinction of being the largest civil landplane in the world.

The "Brabazon" has a wing span of 230ft, the chord at the fuselage being 31ft, approximately equal to the wing span of the Hawker "P1081" jet fighter, and its maximum depth of 6ft 6in enables the four twin "Centaurus" power plants to be completely submerged



THE "BRABAZON 1" MARK 1 AND BRISTOL "F2B" FIGHTER

within the wing profile; the tailplane itself with a span of 75ft is greater in area and 11ft longer than the main wing of the "Canberra" bomber, whilst the rudder stands 50ft high. These dimensions and the maximum all-up weight of 290,000 lb, of which about 60 tons is contributed by a maximum fuel capacity of 13,500 gallons, provide some impression of the size of the machine. At sea level the maximum take-off power developed by the "Centaurus" power units is 18,880 b.h.p. and is roughly comparable to the power available to a 20 knot liner of some 20,000 gross tonnage, 550 to 600ft long.

Upon its present undercarriage, consisting of twin main wheels (60in by 35in) on each of two legs (55ft centres) with twin tyres on each wheel, the "Brabazon" displayed outstanding versatility when manœuvring on the 50-yard perimeter tracks at London Airport. Taxying was smooth, fast and without noticeable lateral accelerations when turning, and without pausing for "running up" or alignment purposes the machine left the taxiway and took off. The acceleration was again barely perceptible and from the engine noise it seemed that many yards of runway were used before the engines were given full throttle. Using 10 deg. of flap the aircraft climbed away at about 150 m.p.h., the ground run being 1000 yards. There was evidence of some turbulent cloud during the afternoon and the "Brabazon," in spite of its mass, was not immune to the bumps, which, on their occurrence, made standing difficult.

Within the machine all the original research and development equipment had been retained. The thirty passengers during each flight were seated just forward of the tail in a relatively small lounge improvised for this occasion, a corner of which is shown in our first illustration.

This small portion of the fuselage was the only length sound insulated and consequently, the engine noise, particularly during the climb, was quite noticeable. The vibration during level flight appeared no greater than that evident on any large piston-engined aircraft.

The original design of the "Brabazon" Mark I provided for 100 passengers and a crew of fourteen, including five stewards; it included a forward lounge, a dining saloon and lounge bar under which were the toilets, powder room and galley, and an aft lounge equipped with cine-projector and radio. Segregated forward were the crew's sleeping quarters and rest rooms, whilst the mail and baggage compartments were situated below decks. Most of this space now accommodates over 1000 flight-recording instruments, which are suitably grouped and automatically and continuously filmed.

Considerable progress has been made on the installation of the pressurisation and air-conditioning system and preliminary testing has begun. The system is designed ultimately to give full differential pressure of 5½ lb per square inch, maintaining an equivalent cabin altitude of 8000ft when operating at 25,000ft. The length of the "Brabazon" will increase by ¾in when under the full differential pressure.

During the flight the aircraft flew at 200 m.p.h. at about 2000ft, and passengers were afforded an excellent view of London and the surrounding country. For maximum performance, however, the "Brabazon" Mark I cruises at 25,000ft with 50 per cent engine power with an air speed of 250 m.p.h. Under these conditions it has a still air range of 5500 miles, sufficient to attempt the direct crossing from London to New York, a distance of 3450 miles, without refuelling, the reserve being due in part to the existence of steady high-velocity winds prevailing on the route which at 25,000ft attain speeds between 70 and 80 m.p.h.

On returning to the circuit the "Brabazon" reduced speed to 150 m.p.h. made a normal powered approach, and with 40 deg. of flap finally touched down smoothly at a speed in the region of 105 m.p.h. The landing run is reduced by the use of its inboard engines, which are fitted with Rotol reversible pitch propellers. The loaded stalling speed with full power, flaps and undercarriage down, lies between about 80 and 85 m.p.h.

The flaps and undercarriage are hydraulically operated, the flaps being divided into three sections on each wing, and symmetrical sections can be operated independently. Should the hydraulic system fail lowering of the undercarriage is effectively achieved by gravity, it being only necessary to release the retaining locks in the wing. A double-tyred, four-wheeled bogie for each main leg has now been developed which will be fitted to the "Brabazon" Mark II aircraft. An unretractable version of this undercarriage is to be temporarily installed in the Mark I machine for extensive landing and take-off tests. Thus fitted it is estimated that the loading distribution will enable the Mark II aircraft to operate from any runway strong enough to bear a "Stratocruiser." A further apparent modification to the Mark I machine has been the removal of the long nose tube containing the pitot head, to facilitate the installation of the Decca Navigator system; air speed is now measured by the normal pitot tubes.

Substantial progress has also been made on the development of gust-alleviation equipment. The only external indication of this is a detector vane of wing section which protrudes from the fuselage near the pilot's station and thus registers the effect of gusts a fraction of a second before they reach the mainplane. When the complete mechanism is installed, the reaction of the vane will immediately be translated to the ailerons, the position of which will automatically alter to counteract the effect of the gust.

A Materials Testing Laboratory

A LABORATORY for the testing of engineering materials has recently been reopened by Messrs. Sandberg, consulting and inspecting engineers, of 40, Grosvenor Gardens, London, S.W.1. Testing and research work, largely of a metallurgical nature, was carried out by that firm for many years prior to the war; the laboratory was taken over by the Ministry of Supply in 1939 for the duration of the war and kept some time thereafter. It has now been modernised and new equipment has been installed to deal with a wide range of testing, including civil engineering materials, such as concrete, bricks and aggregates.

The chemical laboratory is equipped for analysis, mainly inorganic, of engineering materials in general. The test house plant includes a Denison 50-ton universal testing machine, Vickers and Brinell hardness testing machines, an Izod impact machine, and a 150-ton compression testing machine. There is, in addition, a small machine shop containing various ancillary items of equipment. A further laboratory in which the work will be mainly devoted to microscopic examination, with a photographic section, will be opened in the near future.

Work recently carried out at the laboratory included the calibration of an electrical weighbridge, which was exhibited at the recent conversazione of the Institution of Civil Engineers. This equipment comprises strain gauges mounted in four sealed load cells, one at each corner of the bridge, coupled to a balancing box, amplifier and meter. The weighbridge is easily portable and can be used without any specialised knowledge. This particular example is intended for use as a 20-ton mobile weighbridge, though loads up to 1200 tons have been measured successfully with this kind of equipment. Other examples of the laboratory's work have included an investigation of a new metallurgical process, design of concrete mixes to suit certain aggregates, and an investigation into the presence of sugar as the cause of a concrete failure. In addition, the laboratory carries out routine analysis and testing of samples of materials sent by the firm's inspectors at home and on the Continent.

Teaching Engineering Drawing

A STUDY OF THE ALLOCATION OF STUDENTS' TIME

By F. ROBINSON, B.Sc. (Eng.),*

THE study of engineering drawing and practical geometry occupies a considerable portion of the time of the mechanical engineering student. For example, this subject normally occupies about one-third of the timetable of the first two years of National Certificate courses, and the proportion is rarely less than one-fifth of first-year diploma or degree courses. In view of the increasing demands on students' time, it was decided to carry out an investigation of the methods of instruction in order to decide whether there was any way in which the time allocated to this subject might be shortened without lowering the standards of attainment. With this end in view, experiments were carried out to find out in detail how the time spent in drawing classes is employed.

First Series of Experiments

In the first series of experiments stop-watch time studies were carried out on individual students working in engineering drawing classes. Some interesting preliminary observations were made, but the method proved to be unsuitable and was abandoned because :—

(*a*) Students conscious of being observed made special efforts and some became extremely nervous. Their normal routine could not be observed.

(*b*) The time available was not sufficient to allow for the taking of the very large number of studies required to give reliable results.

Second Series of Experiments

This set of experiments was carried out to determine whether the snap reading technique† was a suitable method to use in the investigation, and, if so, the number of observations required for a satisfactory study and the probable accuracy of the results. The technique used may be briefly described as follows. Student activities in the drawing-office were classified under nine headings or operations :—

(1) *Draw.*—Pencil in contact with paper, being positioned or in motion.

(2) *Study.*—Studying the instruction sheet or drawing.

(3) *Idle.*—Personal time. Activities unconnected with the exercise.

(4) *Scale.*—Scale being positioned or in use.

(5) *Position.*—Tee-square or set-square being moved or positioned.

(6) *Set Instruments.*—Setting spring bows or compasses to correct radius either on drawings or to the scale.

(7) *Use Instruments.*—Draw or mark off with spring bows or compasses.

(8) *Erase.*—Erasing or wiping of drawing.

(9) *Adjustments.*—Cleaning instruments. Sharpening pencils. Changing paper, &c.

Random observations were made of students in class, and the operation on which individual students were engaged at the instant of observation was recorded. At the end of the study the number of readings against each operation was converted into a percentage of the total readings. These percentage readings were taken as an estimate of the percentage of the total time spent on each operation.

It was recognised that, in addition to sampling and observation errors, there would be errors because the conditions of statistical control were not accurately met. Consequently, the normal methods of estimating the accuracy of the results could not be applied.

For the first test a class of forty students was studied and the percentages were calculated at intervals during the study. The recorded observations are given in Table I and the corresponding percentages in Table II.

For the second test classes of approximately forty students were each divided into two groups. Both groups of each class were given the same exercises under identical conditions, and different exercises were used for each class. The results of the snap reading studies carried out on the groups are given in percentage form in Table III.

From these results it was deduced that the snap reading technique would be satisfactory for the investigation, provided that about 2000 observations were taken for each study. It appeared that the probable accuracy of the results for operations 1, 2, 3 to 9 combined, would probably be within 3 per cent of the total, but that the percentage times for operations 3 to 9 individually would be very approximate and could be considered only as an indication of the order of the percentage time allocated.

Third Series of Experiments

The snap reading technique having been adopted, actual studies were then carried out on the following classes :—First-

Table I

Operation	Observations							
1	55	120	226	317	405	542	719	828
2	57	110	203	292	388	488	695	745
3	42	75	131	174	237	301	356	379
4	22	39	75	89	108	139	206	224
5	26	50	91	124	159	203	274	336
6	6	22	43	57	75	97	135	153
7	14	31	63	88	108	146	232	295
8	12	32	46	65	81	96	124	148
9	29	37	48	55	64	85	104	106
Total ...	268	516	928	1261	1625	2097	2845	3214

Table II

Operation	Percentages calculated from Table I							
1	20·5	23·2	24·3	25·2	24·9	25·8	25·2	25·7
2	21·3	21·3	21·9	23·1	23·8	23·3	24·4	23·2
3	15·7	14·5	14·1	13·8	14·6	14·4	12·5	11·8
4	8·2	7·6	8·1	7·1	6·7	6·6	7·3	7·0
5	9·7	9·7	9·8	9·8	9·8	9·7	9·6	10·4
6	2·2	4·3	4·6	4·5	4·6	4·6	4·7	4·8
7	5·2	6·0	6·8	7·0	6·7	7·0	8·2	9·2
8	6·4	6·2	5·2	5·1	5·0	4·6	4·4	4·6
9	10·8	7·2	5·2	4·4	3·9	4·0	3·7	3·3
Total ...	100	100	100	100	100	100	100	100

Table III

Operation		1	2	3	4	5	6	7	8	9
Class A	Group 1	29·4	36·4	3·2	7·8	7·0	2·7	7·7	2·5	3·3
	Group 2	27·3	36·4	1·8	9·7	10·9	2·8	6·5	2·5	3·3
Class B	Group 3	32·8	26·6	3·8	7·6	12·3	2·3	8·5	3·7	2·5
	Group 4	32·5	28·1	1·9	12·8	10·8	1·3	6·7	4·1	1·9
Class C	Group 5	24·9	41·0	2·6	7·5	9·4	2·8	6·6	3·4	1·5
	Group 6	25·4	38·6	1·9	6·0	11·2	3·7	7·7	4·4	1·1

Table IV

Class	Percentage times taken by various classes for Operations 1 to 9								
	1	2	3	4	5	6	7	8	9
S1	24·2	23·4	15·3	5·5	12·5	3·4	7·4	4·5	2·9
S2	28·2	24·6	10·5	5·9	12·1	2·8	8·4	4·7	2·6
Mining	22·9	28·4	7·3	9·0	12·5	3·4	9·1	5·6	2·3
Engineering ...	26·2	27·0	9·5	7·8	9·1	4·8	8·6	4·1	2·9
Average of all readings	25·2	26·4	9·9	7·4	11·2	3·8	8·6	4·7	2·8

* Lecturer, Mechanical Engineering Department, Kings College, University of Durham.

† A Snap Reading Method of making Time Studies of Machines and Operatives in Factory Surveys. L. H. C. Tippett. Journal of the Textile Institute. Feb. 1935.

Year Evening Mechanical Engineering S1 students, Second-Year Evening Mechanical S2 students, First-Year Mining Degree students, First-Year Engineering Degree students. During the studies, students were engaged on exercises requiring orthographic projections to be made from pictorial views supplied. In order to neutralise the peculiarities of any one exercise a number of exercises were in progress in each class during the studies. The exercises were chosen to be, as near as could be estimated, of the standard suitable to the ability of the class.

The results of these studies are given in Table IV.

Fourth Series of Experiments

Further snap reading studies were made on engineering degree students in order to obtain additional information with regard to operation 2. The class was given instruction sheets showing orthographic views of machine parts, from which modified views had to be drawn. The exercises were so arranged that for a period of time students were merely copying from the instruction sheet. Separate studies were taken during the period spent on copying and during the period spent on normal activities. The results obtained indicated that approximately two-thirds of the "study" operation was spent in memorising details on the instruction sheet for transference to the drawing board.

Comments on Results

If it is accepted that students are profitably employed only when engaged on operation 1 and that portion of operation 2 which involves thinking about the problem as distinct from memorising details for copying, then it appears that by reducing the proportion of time occupied by the other operations, appreciable saving of overall time could be achieved. In addition, the results in Table IV and in the previous paragraph give an indication of the order of the improvements that could be made under various headings.

For instance, the use of radius templates in lieu of spring bows and scale would probably effect a reduction in the percentage times for operations 6 and 7, but it is unlikely that it will be more than about 5 per cent. Similarly, since the time occupied on operations 4 and 5 combined, represent approximately 20 per cent of the total time, the effect of introducing some simple drawing machine into student drawing-offices is worth study.

The most profitable change, however, appears to be in the nature of the instruction sheets. It is suggested that the provision of drawing paper, on which portions of the exercise that otherwise would be copied were reproduced, would result in a reduction of some 15 per cent of the students' unproductive time.

Development work along the lines indicated above is being carried out, and it is hoped that the publication of these results will encourage others to adopt a similar approach to the problem.

The author is indebted to Professor A. F. Burstall for his help and suggestions regarding the investigations; also to Mr. E. Cardwell late Head of the Engineering Department, Newcastle Technical College for providing facilities for the studies on National Certificate students.

A Rotary Snow Plough

A number of rotary snow ploughs of high capacity have been ordered from J. J. Johnston and Co., Ltd., 271, Uxbridge Road, London, W.12, by the Ministry of Supply. The complete unit is of American design and is being produced in this country by arrangement with the Bros Company, of Minneapolis, Minnesota, U.S.A. Both the carrier and the rotary plough are to be made at Steels Engineering Products, Ltd., Sunderland.

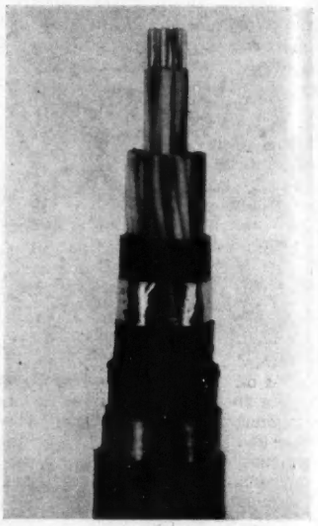
Two Meadows six-cylinder petrol engines, each developing 135 b.h.p. at the maximum governed speed and driving through Vulcan-Sinclair hydraulic couplings of the traction type, will supply the power for the ploughing motions. In the Bros design a double vee mould board is used, carrying two large-diameter rotors, which throw the snow through the dissipating chutes to one or other side a distance of from 75ft to 150ft, depending on conditions. First contact with the snow or ice is made with a feeder "rake," which moves in an arc from ground level to a height of 8ft 3in, permitting the undercutting of high banks. All motions are hydraulically controlled by push button from the operator's cab. When fitted with gathering wings the width of cut is increased from 9ft to 14ft and when used for runway clearance they can be raised hydraulically to clear landing and perimeter lights.

The plough is mounted on a four-wheeled drive carrier, which has been designed for this particular duty, and is also fitted with a Meadows 135 b.h.p. engine, identical and interchangeable with the ploughing engines. An auxiliary gearbox is incorporated to give an exceptionally low overall gear ratio, permitting very slow travelling speed at high engine torque, which is essential for this class of work.

Rotary Snow Plough

Plastic Insulated Telephone Cables in Denmark

For current extensions to its communications system the Copenhagen Telephone Company is laying a new plastic insulated carrier-frequency multi-quad underground cable. Two cables, one for each direction of transmission, have been developed and manufactured by the Telegraph Construction and Maintenance Company, Ltd., at Telcon Works, Greenwich. The cables are insulated and sheathed with "Telcothene" (a tough flexible synthetic thermoplastic based on polythene which is unaffected by water), and are designed to provide forty-eight speech channels per pair in a frequency band from 12 kc/s to 204 kc/s, giving a total of 1152 circuits for the two twelve-quad cables. Present experimental work on the use of carrier type "Telcothene" cables indicates that a total of sixty speech channels per pair will be achieved, thus giving some 1440 circuits using two twelve-quad cables.



Section of 12-Quad Plastic Insulated Underground Cable

Conductors of diameter 0·040in (25 lb per mile) were chosen instead of the usual 0·050in (40 lb per mile), since the distance necessitates an intermediate repeater in either case. To minimise cross-talk a high degree of balance is required; this condition is obtained partly by careful manufacture and partly by special balancing in the field.

Each copper conductor is insulated by an extrusion of "Telcothene" to a diameter of 0·102in, opposite cores in any one quad being coloured similarly for identification of pairs. Four cores are laid up round a separately extruded "Telcothene" cord to form the quads, which are left unfilled so that there are air spaces in the interstices. Different suitable lengths of lay are used for each quad. Twelve quads are laid up, three in an inner layer and nine in an outer layer, and bound together with a thin "Telcothene" tape. Over this tape is extruded a tubular "Telcothene" sheath of 0·065in radial thickness, which is applied sufficiently tightly to lock the quads lightly into position, thus ensuring, during subsequent processing and laying, the stability essential with a high-grade balance. A screen of thin copper tapes is lapped over the sheath and protected by alternate layers of compound and bitumenised paper tape.

For laying in trench the cable is served with compounded jute, armoured with two steel tapes, each 0·030in thick, and finished with two compounded hessian tapes. The overall diameter is approximately 1·63in and the weight 4·0 tons per mile. For drawing into ducts the cable is finished with an outer sheath of polyvinyl chloride of 0·10in radial thickness, extruded directly over the copper tape screen. In this instance the overall diameter is approxi-

mately 1·35in and the weight 2·2 tons per mile.

The dielectric constant of "Telcothene" being 2·3, the capacitance and low-frequency attenuation of these cables are greater than for the normal paper insulated cable; but owing to the low power factor, the attenuation rises more slowly with frequency, so that, at 200 kc/s, it is no greater than for paper insulated cable with the same size conductors. For 60 db. attenuation the maximum repeater spacing with 25 lb conductors is about 12 miles for forty-eight channel working; with 40 lb conductors it is about 16 miles for forty-eight channel working, or 14 miles for sixty channel working. Because of the very low losses in the dielectric at high frequencies it should be possible, as development proceeds, to operate an increased number of communication channels per pair of wires.

The light weight of the cables, through the absence of a lead sheath, makes installation very easy. We learn that two lengths of 250m were pulled into the trench in half an hour, the maximum tension being only about 400 lb, a fraction of the pull that the cable will stand without harm.

A method of jointing by injection moulding has been developed, suitable for use in the field, when the heat required is supplied by current from a 2kW petrol-driven generator. Conductors are butt brazed in a small electric welder, using fluxless solder, after which the insulation joint is made in each quad as a whole. A quad is placed in a small mould, which is then heated internally by warm gas; meanwhile a "Telcothene" charge has been heated in an injector. When correct temperatures have been attained the injector is placed over the injection hole of the mould and its piston is released. Immediately "Telcothene" emerges from the spew holes, a stream of cold air is played on the mould to hasten cooling; the mould is then opened and the completed quad joint removed. When all quads have been jointed and laid into position a "Telcothene" tube (previously slipped over the cable sheath) is slid back into place. By similar technique in a ring mould the tube is welded to the sheath on each side of the joint, after which the screen, armour, &c., are replaced and made good. Joints can be blocked by injecting a special compound into the "Telcothene" tube.

Should major mechanical damage penetrate the sheath without damaging the insulated conductors, circuit continuity would be maintained, although ingress of water would inevitably reduce carrier frequency facilities until the fault was repaired. To detect and locate sheath faults, bare copper wires have been included in the cable; these wires are available for an insulation guard circuit operating an automatic alarm.

The cables have been designed to carry, if desired, power to supply intermediate repeater stations.

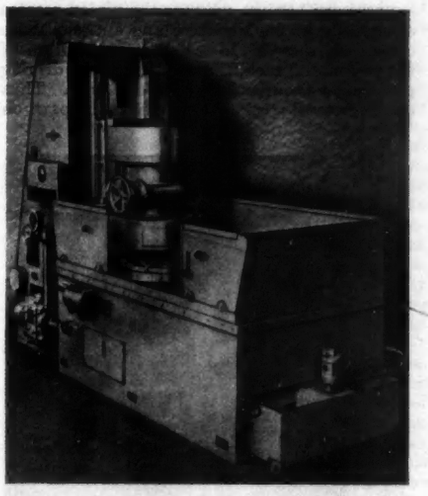
A Vertical Spindle Grinding Machine

THE vertical spindle grinding machine illustrated herewith is a product of the Diskus Werke Frankfurt am Main A.G., and is being marketed in this country by the Rockwell Machine Tool Company, Ltd., of Edgware Road, London, N.W.2. It is largely of fabricated steel construction and has a segmental grinding wheel, 24in diameter with a 40in diameter table.

The rigid main upright of the machine carries the grinding wheel head, which is moved by push-button controls up and down the ways for rough setting purposes, fine settings being obtained by adjustment of the wheel spindle quill. The wheel spindle is driven by a 28 h.p. motor through a flat belt and is supported on large totally enclosed roller and ball bearings.

Fine setting of the automatic feed is through the worm-operated quill in the grinding head, and it can be adjusted from 0·0004in to 0·002in per revolution of the work table. When the preset amount of downward feed of the wheel has been completed an automatic cut-out comes into operation. Wheel dressing is effected by hardened steel rollers, which are swung into operation by a lever and automatically retracted when not in use.

The circular magnetic table can be run out for loading and unloading purposes and is driven through a variable-speed unit, which can be set to run at the required speed for the class of material and kind of job in hand. In the grinding wheel the segments are each bonded to a plastic base and each segment is



24INCH WHEEL, VERTICAL SPINDLE GRINDER

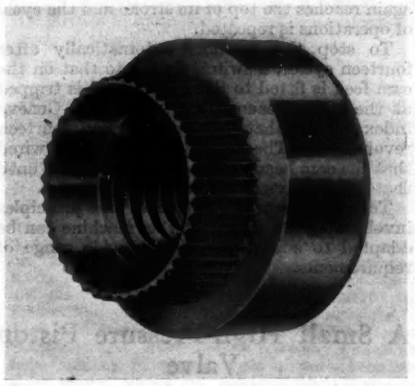
attached to the plastic unit by a single bolt. When segments have been used up they can be removed from the base and replaced by new ones.

All controls are conveniently grouped together on the upright; push-button stations control the coolant pump, vertical adjustment of grinding wheel head, table drive, grinding wheel motor and table runout traverse. A handwheel is fitted for adjusting the speed of rotation of the circular table, whilst the moving of a lever causes the table to run out to the loading position.

Machines of similar design with 16in grinding wheels and 24in tables and 36in wheels and 40in tables are also being manufactured by the firm.

Rivet Bushes

THE photograph we reproduce below shows an improved anchor rivet bush which is now being made by the Precision Screw and Manufacturing Company, Ltd., of Union Street, Willenhall, Staffs. These bushes are used to



IMPROVED RIVET BUSH

provide a substantial threaded hole in sheet metal components which are too thin for normal tapping of holes.

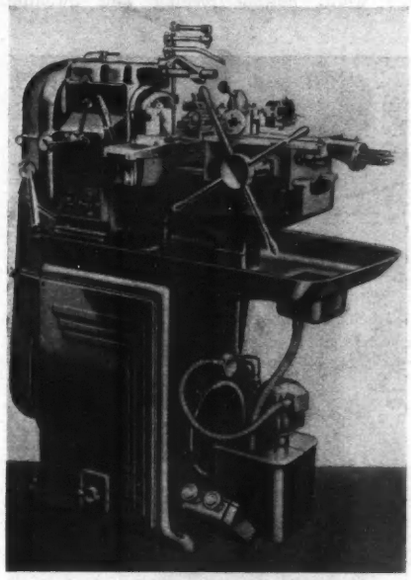
The improved bushes have a slightly tapered serrated shank; when this shank is driven through a hole in sheet metal, it forms corresponding serrations round the circumference. When the shank of the bush is subsequently riveted over, the interlocking serrations hold it firmly when screws are tightened in the tapped bore. The material from which the bushes are made is hard enough to cut the serrations, but sufficiently soft to rivet over with ease.

The bushes are made and stocked in a wide range of standard sizes, tapped from ¼in B.S.W. to ½in B.S.W. or B.S.F. for various gauges and kinds of sheet metal.

A One-Inch Capstan Lathe

THE machine tool division of Murad Developments, Ltd., of Stocklake, Aylesbury, Bucks, has received an order for a thousand of the company's newly designed 1in capacity capstan lathes from the United States. These new machines, one of which is illustrated below, have a height centre of 5½in with a swing of 11½in over the bed and 4½in over the cross slide, and will admit work up to 12½in long between the spindle nose and face of the turret.

The high-tensile alloy steel spindle, which is mounted on preloaded ball bearings, is bored 1 7/16in diameter and its nose is screwed to take



ONE-INCH CAPSTAN LATHE

chucks up to 7in diameter. It can be fitted with a conversion unit to take dead-length collets suitable for work up to ½in.

The main driving motor, which is totally enclosed in the neat cabinet base of the machine, is a three-phase, two-speed, 3 h.p. reversing unit with a speed ratio of 1 to 4. It is controlled through start and stop push buttons and a reversing switch grouped on a panel at the side of the headstock of the machine. A bank of easily accessible oil-immersed contactors on a swing frame in the cabinet control the speed changes and reversal of the motor. Drive is taken through a vee belt from the motor to a countershaft and three-groove pulleys give a choice of speed ratios. Final drive to the rear end of the spindle is through twin vee belts from the countershaft. The three step pulleys and two motor speeds give a range of six spindle speeds, and, with the four drive combinations which are available, machines can be supplied with spindle speeds from 350 to 1385, 225 to 895, 150 to 600, and 85 to 340 r.p.m.

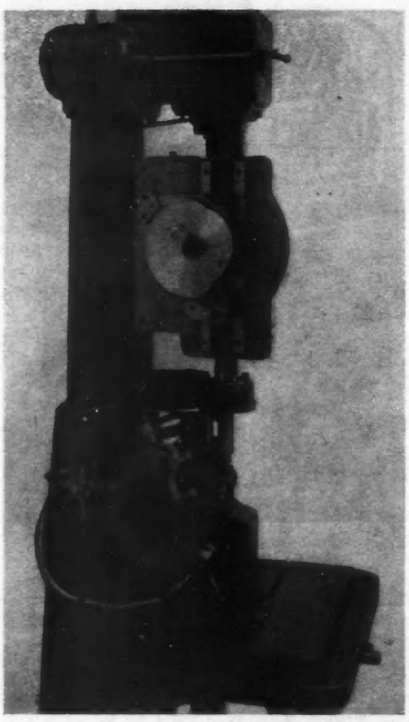
The turret slide carries a 4½in diameter turret and has a maximum stroke of 3½in. In this slide a rectangular index bolt with a separate adjustable jib to take up wear is used to locate the turret by means of radial slots in the index ring. Provision is also made for lateral adjustment of the slide to take up wear. Either a handwheel or a lever-operated cross

slide can be fitted on the machine and this slide has a maximum distance of 5½in between tool posts with a transverse movement of 4½in across the bed.

A Cam-Feed Drilling Machine Head

We have received from Alfred Herbert, Ltd., Coventry, particulars of a cam-feed head which has been developed for its wide range of electric drilling machines. These machines are of unit construction and can be arranged in varying combinations of spindles to form multi-spindle machines for all classes of work.

The cam-feed head shown in our illustration is fitted on one of the firm's "C" drilling machines equipped for drilling fourteen equally spaced holes in the scraper ring groove of a piston. On this machine the feed shaft is driven through reduction gearing by the main spindle and the spindle movements are controlled by two cams. The outer cam, which is clearly visible, controls the downward motion of the spindle and can be designed to incorporate such variations in the speed of the motion as are required for rapid approach to the work, normal feeding and dwelling.



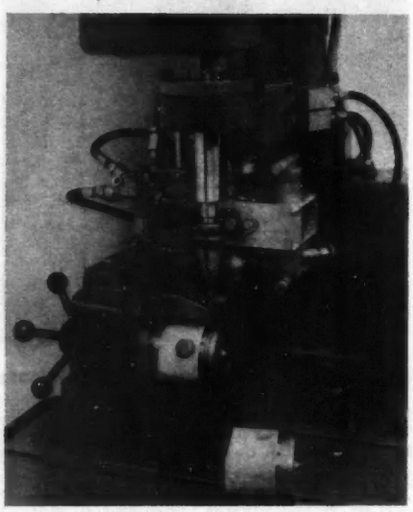
CAM-FEED HEAD

A smaller cam, bolted and dowelled to the inner side of the large cam, controls the spindle withdraw motion. The shaft on which the cams are mounted is driven by the feed shaft through pick-off gears and a worm and worm wheel mechanism. These pick-off gears provide a means of varying the camshaft speed and therefore the rate of feed.

A timing device is fitted to the right-hand end of the camshaft, to stop the machine automatically at the completion of each cycle. This device consists simply of an electrical limit switch, which is tripped at each revolution of the cam by a dog mounted on the camshaft. Methods are also available whereby the machine can be arranged to stop after completing a desired number of continuous cycles.

An air-operated indexing fixture used for drilling the piston is indirectly actuated by the motions of the machine spindle. Indexing is effected by Geneva motion through fourteen positions and takes place in the following way.

In the sequence of operations at the top of the stroke the spindle operates a trip valve mounted on the machine column, and air is fed into the outer end of a cylinder to cause an inward movement of its piston. The air cylinder is secured to the top of the fixture into which a rack extension of the piston projects to mesh with a small pinion, the movement then being imparted to the driving plate and pegs of the Geneva motion by means of a pawl and ratchet mechanism. This form of transmission between the pinion and driving place is necessary because whereas the pinion rotates alternately in the clockwise and anti-clockwise directions, due to the reciprocating motion of the piston and rack, the rotation of the driving plate must occur only in one direction. Thus on the inward stroke of the piston the pawl on



DRILLING FIXTURE

the pinion engages the ratchet on the driving plate and pushes it through approximately 180 deg., thereby rotating the Geneva index plate through one-fourteenth of a revolution. At this point the driving plate is retained by a plunger under light spring pressure, whilst the drill spindle begins the downward stroke. A bar attached to the drill spindle also travels downward and positively locates the Geneva index plate just before the drill commences cutting. At the bottom of the stroke another trip valve is operated which directs air into the inner end of the cylinder and pushes the piston and rack outwards, in preparation for the next indexing motion. This movement also rotates the pinion, but the driving plate is not affected, as the pawl merely trips over the ratchet teeth. Meanwhile the drill spindle again reaches the top of its stroke and the cycle of operations is repeated.

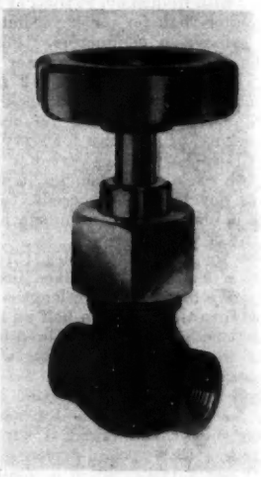
To stop the machine automatically after fourteen cycles, a switch similar to that on the cam feed is fitted to the fixture, and is tripped at the end of each revolution of the Geneva index plate—that is, once every fourteen revolutions. The two switches are so wired that the cam head switch does not operate until that on the fixture has also been tripped.

The makers point out that the principles involved in the design of this machine can be adapted to suit a particularly wide range of requirements.

A Small High-Pressure Piston Valve

A small piston valve, particularly intended for use with high-pressure instrument installations, has been introduced by Richard Klinger, Ltd., of Sidcup, Kent. This ⅛in bore valve has a forged steel body with a 5mm stainless steel piston and is screwed for ¼in or ⅜in B.S.P. or A.P.I. connections. Its bonnet is of carbon steel, whilst stainless steel has been used for the bonnet nut, lantern bush and the spindle.

Each valve is tested hydraulically to 9000 lb per square inch by the makers, who say that it can be used for oil working pressures up to 5000 lb per square inch or superheated steam up to 2000 lb per square inch. It is claimed that by using a spindle of larger diameter than



⅛IN BORE HIGH-PRESSURE VALVE

the piston greater strength and a long working life are ensured, as the load exerted on the thread is very small when operating the valve.

The design is such that throttling has no adverse effect on the efficiency of the valve, as wire-drawing is experienced only on the bottom of the piston, whereas the sides of the piston, which actually seal the valve, remain unaffected. Maintenance is straightforward and, after long service wear takes place, resulting leakages can be corrected immediately by tightening the bonnet nut to compress the two valve rings more closely around the piston.

Automatic Control

The Presidential Address at the recent conference on "Automatic Control" was delivered on July 16th by Sir Ben Lockspeiser. The following is an abstract.

This conference has been organised by the Department of Scientific and Industrial Research, with the support and co-operation of the Institution of Electrical Engineers and the Institution of Mechanical Engineers, to discuss and, it is hoped, notably to advance the development of automatic and manual control systems. The fact that it has been possible to gather together this body of upwards of 300 engineers, scientists and mathematicians from many fields of activity and from most of the leading industrial countries of the world is a clear indication of the present importance of this subject, and of the expectations that may reasonably be held as to the contribution that automatic control may make to industrial progress.

The conception of automatic control arises basically from the use of devices which measure the departure of the physical state of a system from a desired normal, and the utilisation of this information to restore, by mechanical or electrical means, the system to the normal state. There is nothing new in this. Many and varied devices of this kind have existed for a long time. Every steam engine had its governor and a patent was filed for a d.c. cross-field generator to give constant current as far back as 1882. The automatic pilot was flying aeroplanes in 1925 and one of the several fields of automatic control that was already entering upon a phase of active development before the war was that of the automatic control of quantities involved in the manufacture of chemical products, the field now often referred to as process control. The control

equipments for both aeronautical and industrial use were mainly of the pneumatic type. An important paper dealing with this subject by Callender, Hartree and Porter was published in this country in 1936. So far as electrical systems were concerned, automatic control problems were represented in the early development of automatic voltage and current regulators of various kinds and in the development of various special d.c. machines. The origins of modern rotary amplifiers like the metadyne and the amplidyne can be traced back to the earliest years of electrical engineering.

All these developments, highly meritorious in themselves, occurred, however, along several separate paths in parallel, with little or no recognition of any underlying unity of principle. What is new is the emergence in recent years of a philosophy of automatic control, a change of outlook based on the recognition of a common basis of principle in a great variety of engineering devices. And it is precisely this recognition that is mainly responsible for the present acceleration of progress in all the many fields of application from sensitive self-balancing bridges for measuring purposes to power machinery like rolling mill drives.

It is probable that the development of the feed-back thermionic amplifier was the decisive contribution in weaving these various strands of development into a unified pattern. The main theoretical concepts that enable us to deal so effectively with so large a variety of control problems were nearly all first developed in connection with the use of feed-back in amplifiers. It was in this connection that Nyquist, in 1932, developed the criterion of stability, now known by his name, that has played so important a part in the development of all forms of automatic control.

The perception of the essential identity of the basic problems in these various fields was accelerated by the pressure of war requirements. The rapid solution of many automatic and manual control problems became of first importance, as may be appreciated on recalling such examples as the automatic gun layer, the automatic tracking of targets or the control of guided missiles. The solution of these problems led to the production of many new elements suitable for use in control systems. But the outstanding result of the stimulus of war on the development of automatic control was this appreciation, for the first time, of the essential unity of the subject, including mechanical servo-systems, automatic controls as used in the chemical industry, feed-back amplifiers, both of the thermionic, rotary-machine and static-magnetic types, and, in fact, the possibility of bringing under the control of a common scheme of analysis all those systems in wide fields of engineering and elsewhere that involve what is called a "closed sequence of dependence."

The scope of this conception was soon seen to extend even beyond engineering. There is no doubt that in biology, in economics and, perhaps, even in still wider fields, this conception of the closed sequence of dependence, and the characteristics of system behaviour associated with it, may prove to be a valuable tool of thought, and in some cases a means to the formulation of problems in these difficult fields in such a way that the analytical methods already worked out by engineers may be brought to bear on them.

I am glad to see that the organisers of the conference have recognised these wider implications of the theory of closed sequence systems by allocating two informal evening sessions to discussion respectively with biologists (with a lecture by Professor J. Z. Young) and with economists (with lectures by Mr. J. R. N. Stone and Professor A. Tustin). I feel sure that the rubbing of minds of representatives of such diverse sciences in informal discussion of this kind will be all to the good.

The conference covers a wide field, but the emphasis of the papers is on general concepts and on methods of analysis, rather than on specific applications. The organising committee was particularly anxious to bring together in the same conference engineers working in the very important field of process control and engineers concerned with the control of mechanical and electrical quantities in the field usually roughly designated by the term "servo-systems." The third day of the conference is therefore wholly devoted to problems of process control. There are at present somewhat disconcerting differences of nomenclature and points of view between these two distinct families of engineers, and it is to be hoped that the discussions at the conference, both formal and informal, will enable them to learn each other's language, perhaps in some cases to adopt common terms and to be of greater mutual assistance to each other in the future than they have been in the past.

The subject of automatic control is of outstanding importance, both in connection with industrial development and the increase of productivity, and also with defence requirements. Writers of eminence have not been lacking, particularly in the United States, who have seen in the development of automatic control systems an important contribution to the emergence of an entirely new type of industrial era. There is some disparity between such views of the future potentialities of automatic control and the somewhat slow, though steady and important, progress that has been made so far in the application of automatic controls in industry.

It may be true that if economic considerations are set aside there are now only remote limitations to the technical possibilities of devising mechanisms that will carry out certain kinds of functions usually performed by human muscular skills, but, in fact, the economic considerations remain, and it is an important purpose of a conference of this kind to make the sort of progress that in the long run will result in the production of simple and, therefore, cheaper equipment. Several of the papers discussed during the conference are concerned with the alternative ways in which a given specification of requirements may be met and the possibilities of devising procedures in design that will indicate the optimal design without the inordinate amount of labour and calculation that is at present involved in the design of such systems. Such developments, if they can be carried to a successful conclusion, will also help to cheapen the application of automatic control and so widen its field of use.

Finally, the assurance of further progress in any field lies in the continued supply of men trained and educated in the present knowledge of the field, but trained also in a truly scientific outlook and in that appreciation of the mathematical and physical fundamentals from which further progress springs. It is particularly appropriate, therefore, that the opening lecture of the conference is to deal with the educational problems that are raised by the present importance and the probably still greater future importance of automatic control. It is fortunate that it has been possible for us to have with us to give this lecture Professor Gordon Brown, of the Massachusetts Institute of Technology. His pioneer work in meeting the new educational needs in this field is well known.

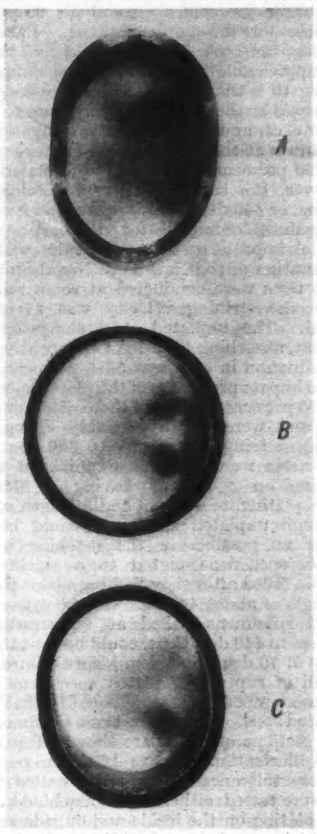
Post-Graduate Courses in Hydro-Power Engineering.—Hydro-electric works are of such magnitude and intricacy and require so many engineers in their design and execution that, in many countries, an acute shortage of specialists has developed. A course of post-graduate training for such work is now provided at the Imperial College of Science and Technology, University of London, where men who have already taken a degree in one of the relevant branches of engineering may study the many aspects of the civil, mechanical and electrical engineering design peculiar to this field. The courses, which were inaugurated in 1946 with the co-operation of the English Electric Company, Ltd., have already provided a considerable number of young hydro-power specialists. Each course covers one session. No syllabus in hydro-power engineering can, in that time, fully cover all the aspects to be touched on, and the aim is to provide a broad and up-to-date view of the whole field with some training in the approach to detailed investigations of problems of the student's own choice. The subjects studied include applied fluid mechanics; surges, water hammers and waves; hydraulic structures; hydraulic machinery; and electrical power. A fortnight's study tour is also included.

American Engineering News

(From our American Correspondent)

Plastic Deformation of Chromium-Plated Steel

Although chromium-plating, because of its hardness and ease of application, is widely used to-day to protect softer metals from wear and to salvage worn or undersized parts, the advantages of the treatment are sometimes offset by a resulting reduction in the ability of the base metal to deform plastically without breaking. In an investigation of the effect of chromium-plating on the plastic deformation of steels used in aircraft, Mr. H. L. Logan, of the National Bureau of Standards, recently made a comprehensive study of the mechanical properties of chromium-plated SAE 4130 steel. The results of this



Failure of Crushing Test Specimens

investigation, which was sponsored by the Bureau of Aeronautics, U.S. Department of the Navy, provides information of interest not only to aircraft manufacturers, but also to a number of other industries which produce or use chromium-plated machine parts. The investigation included tensile, tensile impact, bending and crushing tests of specimens prepared from rod and tubing of SAE 4130 steel, heat-treated to a hardness of about 40 on the Rockwell "C" scale before the final machining. SAE 4130 steel contains 0·3 per cent carbon, 0·5 per cent manganese, 0·95 per cent chromium, and 0·2 per cent molybdenum. Some of the specimens were tested as machined, without plating; others were tested after plating to one or more thicknesses, and still others after both plating and subsequent baking at various temperatures up to 440 deg. Cent. The effect of baking was of interest since the usual commercial practice is to bake chromium-plated steel articles at a temperature of 200 deg. Cent. for several hours after plating. Chromium was deposited from a bath containing 250 grammes per litre of CrO_3 and 2·5 grammes per litre of H_2SO_4, which was maintained at 55 deg. Cent.; a current density of 350A per square foot was used. The data obtained in all except the

tensile impact tests indicate that chromium-plating appreciably reduces the plastic deformation that can occur in SAE 4130 steel before fracture. Generally, however, the ability of the plated specimens to undergo plastic deformation was substantially increased by baking at temperatures between 100 deg. and 440 deg. Cent.

Tensile tests were made on specimens plated to nominal thicknesses of 0·0001in to 0·015in, as well as on the unplated specimens. Average values for the tensile properties of the unplated steel were as follows:—Tensile strength, 187,300 lb per square inch; yield strength, 175,900 lb per square inch; elongation in a 2in length, 13 per cent; true stress at beginning of fracture, 270,900 lb per square inch; original area of specimen divided by area at beginning of fracture, 2·088. It was found that the tensile and yield strengths decreased with increasing plate thickness until, at a thickness of 0·015in, the values were about 90 per cent of those for the unplated steel. Baking at 200 deg. and 400 deg. Cent. did not produce any appreciable change in these properties. Plating to a thickness of 0·010in reduced the true stress at the beginning of fracture to about 80 per cent, and the percentage elongation and true strain at the beginning of fracture to less than 60 per cent of that of the unplated steel. However, the baking of plated specimens at 200 deg. or 440 deg. Cent. appreciably increased the values obtained for these properties. Tensile impact tests were made with the co-operation of the New York Naval Shipyard. These tests were conducted at room temperature; the striking velocity was 27·8ft per second. The unplated steel elongated 15·8 per cent, absorbing 464ft-lb of energy at failure; the reduction in area was 55·2 per cent. The tensile impact properties of the plated specimens were 93 per cent or more of those of the unplated steel and were not appreciably changed by baking at temperatures up to 300 deg. Cent. Bend tests were made in a universal testing machine on specimens having a diameter, before plating, of 0·500in and a length of 10in. Although unplated specimens could be bent as far as possible in the machine without failure, specimens plated to a thickness of 0·015in failed after they had been bent through an angle of about 40 deg. On the other hand, plated specimens baked at temperatures of 200 deg. to 440 deg. Cent. could be bent through angles of 70 deg. to 85 deg. before failure. The moduli of rupture of plated specimens baked at these temperatures were equal to that of the unplated steel. In crushing tests, specimens, the cross sections of which are shown after failure in the illustration on page 163, were machined to close tolerances from heavy-walled tubing and were tested either (*A*) as machined, or (*B*) after plating on the inside and outside surfaces to a thickness of about 0·010in or (*C*) after plating to this thickness and baking at temperatures between 100 deg. and 400 deg. Cent. The specimens were tested to failure by compression between the stationary and movable heads of a universal testing machine in which the load was applied along a diameter of the tube. Plating increased the load necessary to crush the specimen by a factor of about 1·2 and reduced the deformation at failure to approximately 9 per cent of that of the unplated steel. Baking at temperatures of 200 deg. to 400 deg. Cent. increased the load necessary to produce failure about 1·4 times and increased the deformation to about 55 per cent of that of the unplated steel. It is considered possible that hydrogen deposited with the chromium during plating may be a factor in reducing the amount of plastic deformation that the steel can withstand before fracture. Baking of plated specimens would remove the hydrogen from the chromium and, hence, may be expected to increase the ability of the steel to withstand plastic deformation.

Start of Pumping at Grand Coulee Dam

At a signal from the Secretary of the Interior in Washington, the first unit of the Grand Coulee pumping plant went into regular operation on June 14th, lifting water 280ft from Lake Franklin D. Roosevelt into a canal which flows into the Grand Coulee. The Coulee has been turned into a storage reservoir with dams at both ends and the water will be stored there for use during the irrigation season. The first large-scale irrigation is contemplated next year when facilities will be available for supplying water to 87,000 of the 1,000,000 acres of the project. Geologists believe that during the Ice Age a glacier blocked off the river channel at approximately the site of Grand Coulee dam, and diverted water across what is now known as the Big Bend country of central Washington. In the course of centuries before the ice barrier melted, the swift-flowing river etched out a wide channel several hundred feet deep. It is this wide channel which is now being put to use as a reservoir. Through the balancing effect of this equalising reservoir off peak power which would otherwise be wasted will be used to the maximum extent to pump the water, building up a supply which will flow by gravity to the Columbia Basin Project lands during the hot, dry growing season. There will be more than 1000 miles of canals and laterals within the project. Ultimately, 1,029,000 acres will be under cultivation. Approximately 6 per cent of the flow of the Columbia River, at this point, will be diverted to irrigate the now dry land. The Grand Coulee, a historic Ice-Age channel of the Columbia River, will become the flume to carry the water, by gravity, toward the project lands to be irrigated. The natural channel has been sealed into a giant storage lake by two earth-fill dams 27 miles apart. The total water lift which was required at the Grand Coulee dam to pump the water back was 630ft. More than half of the lift, approximately 350ft, was accomplished by the building of the Grand Coulee Dam, which now retains water in a 151-mile lake all the way to Canada.

The final lift of 280ft is now being accomplished by pumping. The first six pumps are being built by the Pelton Water Wheel Company of San Francisco, and the Byron Jackson Company of Los Angeles. The first two motors were built by the General Electric Company of Schenectady, New York. The next four are being built by the Westinghouse Electric Corporation, of Pittsburgh. Each of the 65,000 h.p. synchronous motors is 25ft high, has a circumference of approximately 100ft, and weighs more than 300 tons. It is electrically connected to a 108MW generator in the Grand Coulee dam power station downstream from the pumping plant. The pumps are vertical-shaft, single-impeller, centrifugal pumps, each having a designed capacity of 1350 cusecs at a 310ft head. Their maximum capacity is 1600 cusecs at a 280ft head. Through twelve steel pipes, each 12ft in diameter, the water will be carried from the pumps to a headworks, where a feeder canal receives the water on top of the hill. These twelve pipes can carry a flow almost as great as the average flow of the Colorado River at Hoover dam. The pumping plant, which houses the pumps and motors, is adjacent to and behind the Grand Coulee dam. The wing dam, behind which the pumps are installed, was built in 1938–39, when the Grand Coulee dam was under construction. Wartime needs subordinated the completion of the irrigation part of the project to the then developing power demands. To-day, all but two of Grand Coulee's eighteen 108MW generating units are on the line, producing almost half of all the hydro-electric power used in the Pacific North-West of the United States. Only a small part of this power will be used for irrigation pumping, even under maximum development, and most of the power required for pumping occurs at a time of year when the river flow is high and the demand for power is low.

THE HEAT PUMP AT SOUTH BANK.—In connection with our article describing the heat pump at South Bank in the issue of June 29, 1951, Imperial Chemical Industries, Ltd., draws attention to the fact that it supplied the dichlorodifluoromethane used as the working fluid for the pump. This product of the company is known as "Arcton" 6.

French Engineering News

(From our French Correspondent)

The autumn programme for French automobile manufacturers is now being worked out and it is estimated that for a period of about three months the combined French output should be about 2200 touring cars daily. It is therefore hoped that the domestic market will have more cars and that delivery delays will be reduced. The chief problem facing the industry is the supply of steel.

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The French Government has decided to construct several important coking plants, in order to ensure sufficient coke for the French steel industry. At the moment steel production has dropped because of Germany's failure to deliver coke. The new French plants will be constructed in Lorraine, and further new thermal power stations will be built in the same area.

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The French Post Office has announced that successful experiments have now been completed, which will enable telephone subscribers to communicate by telephone with motorists. The plan which has been worked out functions on a 2m wave-band. If a subscriber wishes to call a motorist he will dial a number, which will connect him with the special service. Each motorist will be given a telephone number and the subscriber will then give this. The motorist will then be called by dialling, a flashing light warning him that someone wishes to speak to him. If he wishes to make a call he has only to remove the receiver of his own apparatus and he will automatically call the special service, which will connect him. The Post Office is now studying cost and trying to estimate the number of motorists willing to subscribe.

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The first section of the new short-wave link which will replace the Paris-Lille telephone cables was recently inaugurated. The new system will provide 720 tele-phone channels between Lille and Paris, and has a wavelength of between 7cm and 8·5cm. The present programme envisages similar links with Great Britain through a station at Bouvigny, and with Belgium directly from Lille.

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The production of "hyperphosphates" is to be started in Morocco at Casablanca. A new company has been formed called the "Hyperphosphates of Reno," and it is estimated that some 50,000 tons of hyperphosphates will be produced every year.

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The Renault Regie has ordered diesel motors for its new tractors to the value of £300,000 from F. Perkins, Ltd., of Peterborough. The Perkins motors will be constructed in France under British licence.

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Because of the increase in petrol production in Morocco (expected to be 500,000 tons this year), it has been decided to construct a 2700m submarine pipe-line at Fedala. The pipe-line will be in three sections, of 900m each.

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The Northern and Pas de Calais coal mines, which have recently been considerably modernised, have announced that wage increases, without the need of financial help from the Coal Board, are now possible due to increased production. Over the past five years production per miner has increased, as a result of the modernisation, from 862 kilos to 1200 kilos. This year production is estimated at about 27,559,839 tons, which is about the same as 1950, but the number of miners has been reduced considerably.

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It is reported in Paris that the International Mont Blanc Company will be officially inaugurated in August. Its headquarters will be in Geneva. A meeting of Swiss, Italian and French engineers will take place in Paris at the end of July, when the technical aspects of the proposed tunnel will be discussed.

Industrial and Labour Notes

The Economic Situation

On Thursday of last week there was a debate in the House of Commons on financial and economic affairs. It was opened by the Chancellor of the Exchequer, Mr. Hugh Gaitskell, who made a lengthy statement on the present economic situation, and announced the Government's intention to introduce in the autumn a measure to control dividends.

In the course of his statement the Chancellor expressed the view that the biggest direct check to the expansion of this country's industrial production at the moment was the shortage of steel. Primarily, he said, it was the shortage of imported iron ore and scrap which was limiting steel output, although he thought there was a fair chance of reaching a production of 16,000,000 ingot tons this year. With some reduction in stocks, and with the greatest possible economy in the use of steel, that output, the Chancellor considered, should support an increase of 4 per cent in total industrial production during the remainder of the year.

But, the Chancellor continued, in looking ahead to 1952, there was ground for serious anxiety. Although the output of coal had been increasing, home coal consumption was rising even faster. The first impact of the coal shortage inevitably tended to be on coal exports. In the first five months of this year, Mr. Gaitskell stated, exports amounted to only 2,500,000 tons, against 6,750,000 tons in the corresponding months of 1950. Most of those exports went to Western Europe and occupied a key position in our trade with the countries upon which we depended for many supplies which were absolutely essential to our industries—timber, wood pulp, pyrites, and the bulk of the imported iron ore which was and would be badly needed for producing steel at home. Unless, the Chancellor went on to say, enough coal could be exported, there was a risk of losing those essential supplies and the whole of our industrial effort would suffer in consequence. Somehow or another more coal must be produced and means must be found of reducing home consumption in ways which caused the least damage to our industries.

The Chancellor then referred to the United Kingdom's balance of payments, saying that the Economic Survey had estimated that this year's import bill would amount to about £3,200,000,000, towards which the net invisible earnings might contribute some £450,000,000. That left £2,750,000,000 to be obtained by visible exports and re-exports, an increase of rather over £500,000,000 compared with actual earnings in 1950. It was envisaged that a good deal of the increase would come from higher export prices, but that some increase in volume would also be needed. The rapid rise in import prices during the past six months suggested that, on account of higher prices alone, the total cost of imports this year would perhaps be well over £100,000,000 more than the Survey allowed for, even after making allowance for the reduction in import prices to be expected in the coming months. The invisible account, also, the Chancellor stated, had developed less favourably, and the invisible earnings this year were unlikely now to exceed £400,000,000. In consequence, export earnings would have to be considerably above the Survey target to keep the overseas accounts in balance this year. Export earnings in the first half of the year were only just over £1,300,000,000, and it looked therefore as if £1,600,000,000 would be needed in the second half of the year if our current imports were to be paid for in full.

Dividend Control

Towards the end of the statement on the economic situation, referred to in the preceding note, the Chancellor of the Exchequer spoke about "further steps" which were necessary if we were not "to be continually frustrated in our efforts to check inflation and the increase in the cost of living." He then announced the Government's decision to introduce in the autumn a measure to control dividends.

The control, the Chancellor said, would apply to all companies, public and private, during the re-armament period, which would be defined as three years for each company, and it would impose a limit on the gross amount of dividends which might be distributed, other than fixed rate dividends. In normal cases the limit would be the average of the dividends distributed in respect of the last two accounting periods of the company for which, before July 27, 1951, a final dividend had been paid or declared or announced. For existing companies which had paid no dividend or an abnormally low one, there would be an alternative standard, equivalent to 5 per cent of the relevant capital, which meant, broadly speaking, the paid-up share capital. The control would not apply to companies distributing less than £10,000 gross a year, and in the case of new companies, which might need to raise more capital, the standard would be 7 per cent of the relevant capital. There would also be provision for the Treasury, in exceptional circumstances, to decide that the amount of dividend permissible might be increased, but, the Chancellor added, that power would be exercised only in very special cases.

Changes in Wage Rates

The Ministry of Labour has stated that changes in wage rates reported as taking effect in June resulted in an aggregate increase of about £314,000 in the weekly full-time wages of 1,176,000 workers in the United Kingdom. Among those receiving pay increases were workers in the chemical and allied industries, in ironstone mining and in the iron and steel industry.

The Ministry's statistics show that in the first six months of this year approximately 7,098,000 workpeople received pay increases aggregating £2,785,300 a week. During the period there were no decreases in wage rates reported. In the corresponding months of 1950 there was a net increase of £385,000 in the weekly full-time wages of 2,304,000 workpeople.

Trade Disputes

Stoppages of work through industrial disputes in the United Kingdom, reported to the Ministry of Labour as beginning in June, numbered 159. In addition, there were twenty-five stoppages which had started earlier still in progress at the beginning of June. In these 184 stoppages it is estimated that about 85,000 workers were involved, directly and indirectly, during June, the result being an aggregate loss of 304,000 working days. In June last year there were 146 stoppages of work through disputes, involving 28,700 workers and causing a loss of 95,000 working days.

In the first six months of this year, stoppages of work through disputes numbered 898. They involved 236,900 workers and caused an aggregate loss of 1,220,000 working days. In the comparable period of 1950 there were 761 stoppages reported, involving 148,100 workpeople and resulting in a loss of 588,000 working days.

Iron and Steel Allocation

The Minister of Supply has made the Iron and Steel Utilisation (Information) Order, which permits him to collect certain information on which the allocation of steel can be based. The Order calls for returns of iron and steel consumed during the first half of this year, the amount of stocks in that period, and estimated requirements for the following nine months.

Two returns are required. The first, return "A," is necessary if any undertaking consumed 25 tons or more of non-alloy iron and steel in the half year. A separate return is needed of all the iron and steel, including alloy iron and steel, consumed and held in stock in each of the undertaking's works and stockyards. The second return, "B," is called for if an undertaking consumed either 5 tons of alloy iron and steel or 1000 lb of high-speed steel in the half year. In this case also a separate return is needed for each of the undertaking's works and stockyards. The Ministry states that returns are not required from works using iron and steel only for the main processes of iron and steel manufacture; for iron castings other than alloy iron castings; or from scrap merchants, stockholding or distributing merchants, or from warehousemen.

All the returns must be made, in duplicate, not later than August 22nd, on official copies of the forms "A" and "B" which are being sent direct to all steel-using firms whose names and addresses are known. But firms which have not received copies of the forms by August 8th are asked to write immediately to the appropriate Regional Controller of the Ministry of Supply. The Ministry points out that the making of these returns is a statutory obligation.

Shortage of Railway Staff

When replying to questions in the House of Commons at the end of last week, the Minister of Transport said that drastic steps would have to be taken if the present shortage of railway enginemen continued. For some time and particularly during recent months, heavy industrial areas had made competing demands to attract labour, not only for ordinary industrial purposes, but now for the defence programme, which added still further pressure. There was already a great shortage of locomotive firemen and the Minister said that this class of labour was being attracted into industries with shorter working weeks and high rates of pay. The Railway Executive had been discussing the matter with the unions to see how the position could be alleviated. It had now assumed such grave proportions that it needed Government consideration as to whether deferment from service with the armed Forces of certain key grades on the railways would be necessary. But, he said, it was a serious thing to defer, first, one section of employees in an industry, and then another.

Index of Industrial Production

The Central Statistical Office of the Treasury has estimated provisionally that the index number of industrial production (1946 =100) was 146 for the month of May for all industries in this country, compared with 151 for April. Figures for the corresponding months of last year were 141 and 135 respectively. It should be borne in mind, however, that the figure for April, 1950, was affected by the Easter holiday and that the figures for both years in May were influenced by the Whitsun holiday. In May this year, for the manufacturing industries only, the index number was estimated provisionally as 153. The number for mining and quarrying was 115, compared with 119 in May last year.

The Treasury says that, on the basis of information so far received, the index for all industries for the month of June is expected to be 147 or 148. It is added that in the first half of this year industrial production was rather more than 4 per cent higher than in the first six months of 1950.

Control of Factory and Storage Premises

As part of the defence plans, it has been decided to set up a small organisation within the Board of Trade to make preliminary arrangements should it be necessary to establish at short notice a control of factory and storage premises similar to that which operated during the last war. The organisation will also assist the departments concerned with the provision of storage accommodation in connection with the rearmament programme. Sir Philip Warter, who was Controller-General of Factory and Storage Premises during the last war, has agreed to take charge of the work on a part-time basis.

Notes and Memoranda

Rail and Road

LOCOMOTIVE WHEEL CENTRES.—In the concluding paragraph of our notes on the "SCOA-P" wheel centres for locomotives, in the issue of June 22nd last, the impression was given that K. & L. Steelfounders and Engineers, Ltd., was financially associated with the Vulcan Foundry, Ltd. There is no such association but the two companies collaborated technically in connection with wheel centres. K. & L. Steelfounders and Engineers, Ltd., is a member firm of the "600" group of companies.

CAR PRODUCTION.—The Society of Motor Manufacturers and Traders, Ltd., reports a 7 per cent all in vehicle production for the first half of 1951, compared with the previous year. During this period vehicles were produced at the rate of 2000 per day, amounting to a total for the half year, 1951, of 245,000 cars and 135,000 commercial vehicles. Of the vehicles exported, 186,000 were cars and 70,000 were commercial. The principal cause of the curtailed output was stated to be the shortage of sheet steel.

Air and Water

VENEZUELAN DESTROYERS.—The keels of the two 2600-ton destroyers intended for the Venezuelan Navy were laid on July 24th at the Barrow yard of Vickers-Armstrongs, Ltd., in the presence of the Venezuelan Ambassador. The vessels will be named "Nueva Esparta" and "Zulia."

PRODUCTION OF HAWKER "P1067" JET FIGHTER.—It is disclosed that the Hawker-Siddeley Group is to produce in quantity an interceptor fighter known as the Hawker "P1067." This aircraft, as with the earlier "P1081" experimental machine, has swept-back wings, but is to be fitted with the more powerful Rolls-Royce "Avon" jet turbine.

H.M.S. "VANGUARD."—A scale model of the H.M.S. "Vanguard" has been lent by the builders of the battleship, John Brown and Co., Ltd., to the Science Museum, South Kensington, London, where it is on view among the steamships collection in Gallery 41. H.M.S. "Vanguard" has a length overall of 814·3ft, a breadth of 107·5ft, a draught of 28ft, and a standard displacement of 42,500 tons. She is driven at 28 knots by a four-shaft arrangement of Parsons single-reduction geared turbines of 130,000 s.h.p.

TEST PILOT APPOINTMENTS.—Vickers-Armstrongs, Ltd., has announced the retirement of Captain J. Summers, who has been its chief test pilot for twenty-two years. Amongst his fifty-four first flights were those of the "Spitfire," "Wellington" and, more recently, the "Valiant" four jet engined bomber. His many experiences during this period include several instances of structural failure during spinning and diving tests, and on one occasion he was obliged to force land a "Warwick" aircraft with an enforced rate of descent of 2000ft per minute. Captain Summers remains with the company as chief liaison officer; Mr. G. R. Bryce is appointed chief test pilot at its Weybridge works, and Lieut.-Commander M. Lithgow at the Supermarine Works.

Miscellanea

MANUALS ON WATER SUPPLY AND SEWERAGE SCHEMES.—The Ministry of Local Government and Planning has issued two manuals on procedure for the submission of water supply and sewerage schemes, the use of which, it is hoped, will be of assistance to local authorities in the preparation of schemes, and in obviating correspondence between the authorities and the Ministry. The manuals are entitled "On the Submission and Consideration of Schemes of Water Supply," and "On the Submission of Schemes of Sewerage and Sewage Disposal."

WEST HAM "B" POWER STATION.—In our description of West Ham "B" power station (July 20th issue, pages 82–85) we published a list of contractors reproduced from information provided by the British Electricity Authority, according to which the evaporators were supplied by G. and J. Weir, Ltd. We wish to amplify this acknowledgment, and remove any misunderstanding, by stating that whereas G. and J. Weir, Ltd., supplied the unit evaporators, it was Aiton and Co., Ltd., who supplied the triple effect thermo-compressor evaporators referred to on page 85 of our article. Further, the mechanical stokers were provided by International Combustion, Ltd., and not by the Underfeed Stoker Company, Ltd., as stated in the list of contractors on page 85.

LONDON COUNTY COUNCIL'S ANNUAL RECEPTION.—The annual reception of the London County Council was held on Friday last, July 27th, at the County Hall, Westminster. Some 1500 guests were received by the chairman of the L.C.C., Mr. J. W. Bowen, and Mrs. Bowen, and guests were later joined by H.R.H. Princess Alice and Major-General the Right Honourable the Earl of Athlone. Music and dancing were enjoyed during the evening and guests were able to see an exhibition of objects excavated during the preparation of the South Bank site.

THE LATE MR. S. E. OSBORN.—We have learned with regret of the death of Mr. Samuel Eric Osborn, which occurred in London, following an operation, on July 19th. Mr. Osborn, who was fifty-nine, was the only son of the late Mr. William Fawcett Osborn, and had been chairman of Samuel Osborn and Co., Ltd., Sheffield, since last November. He joined that company in 1910 and succeeded to the chairmanship on the death of his uncle, Mr. Fred M. Osborn. In 1945, Mr. Osborn was Master of the Cutlers' Company of Hallamshire, an office which had been held by his father in 1906 and his grandfather in 1873.

NICKEL PRODUCTION IN CANADA.—At the annual meeting of the International Nickel Company of Canada, Ltd., last April, Dr. Thompson, chairman and president of the Company, announced that by the end of the year the Company's production of refined nickel would be increased by 1,000,000 lb monthly. As a result of intense effort at the Canadian plants in underground mining, metallurgical process changes and emergency facilities, this increase has been achieved only three months after the statement was made. The increase brings the Company's total refined nickel production to 21,000,000 lb. per month.

COAL CLEANING PLANT IN INDIA.—Coal cleaning equipment, the first of its kind to be installed in India, was recently commissioned at West Bokaro Colliery, Bihar. The plant, which was made by the General Electric Company of India, Ltd., operates on the Chance sand flotation process, which is already well established in other countries. The installation is important because of India's rapidly diminishing reserves of good coking coal, the remaining reserves being unsuitable for the work in hand (the Tata Iron and Steel Company's blast-furnaces at Jamshedpur) without being upgraded. In the new cleaning plant the coal is separated at two specific gravities, producing a low ash content coking coal, a medium ash content boiler fuel, and a high ash content residue which is disposed of at the mine.

Launches and Trial Trips

AGUILA, motor tug and water vessel; built by Philip and Son, Ltd., for Compania Sud-Americana de Vapores, Valparaiso; length between perpendiculars 110ft, breadth moulded 25ft, depth moulded 12ft 3in, 234 tons gross, 160 tons fresh water; British Polar diesel engine, 680 b.h.p. at 260 r.p.m., two 70kW d.c. generators, speed 10·7 knots. Trial July 12th.

CAVALLO, cargo ship; built by Henry Robb, Ltd., for Ellerman's Wilson Line, Ltd.; length between perpendiculars 290ft, breadth moulded 48ft 6in, depth moulded to shelter deck 28ft 3in, deadweight 3000 tons on 19ft 6in draught; two eight-cylinder British Polar two-stroke diesel engines, each 1520 b.h.p. at 300 r.p.m., two Vulcan hydraulic couplings, one Vulcan single-reduction twin-pinion single-wheel gearbox. Launch July 19th.

VANJA, motor tanker; built by the Furness Shipbuilding Company, Ltd., for Skibsaktieselskapet Nordheim, Oslo; length between perpendiculars 560ft, breadth moulded 80ft, depth moulded 42ft 3in, deadweight 24,700 tons on 32ft 3½in draught; twenty-seven cargo oil tanks, two pump rooms, four duplex steam pumps, steam deck machinery; Hawthorn-Leslie-Doxford oil engine, six cylinders, 670mm diameter by 2320mm combined stroke, 6600 b.h.p. at 115 r.p.m., two Scotch boilers. Trial July 19th.

BRITISH GUIDE, motor tanker; built by the Furness Shipbuilding Company, Ltd., for the British Tanker Company, Ltd.; length overall 490ft 10in, breadth moulded 61ft 9in, depth moulded 33ft 11in, deadweight 12,135 tons on 27ft 6¾in draught; twenty-seven cargo oil tanks, two pump rooms, four duplex steam pumps, steam deck machinery; Hawthorn-Leslie-Doxford oil engine, four cylinders, 600mm diameter by 2320mm combined stroke, 3300 b.h.p. at 108 r.p.m., two cylindrical boilers. Trial July 23rd.

Personal and Business

MR. J. W. MARTIN, sales manager of Wheasoe, Ltd., Darlington, has been appointed a director of that company.

MR. HUGH FORD has been appointed Professor of Applied Mechanics at the Imperial College of Science and Technology.

THE COZY STOVE COMPANY, Ltd., has joined the selling organisation of Radiation, Ltd., 7, Stratford Place, London, W.1.

MR. B. E. TERRY, A.M.I.Mech.E., has been appointed technical manager in the plastics division of E. K. Cole, Ltd., Southend.

THE INDUSTRIAL PYROMETER COMPANY, Ltd., announces that it will move shortly to a new factory in Gooch Street, Birmingham, 5.

A. C. WICKMAN, Ltd., of Coventry, announces that, on and after June 28, 1951, the name of the company will be changed to Wickman, Ltd.

MR. P. C. ALLEN, Mr. E. A. Bingen, Captain R. C. Todhunter, and Mr. A. T. S. Zeally have been appointed directors of Imperial Chemical Industries, Ltd.

SAMUEL OSBORN AND CO., Ltd., Sheffield, announces the appointment of Mr. F. A. Hurst as chairman, in succession to the late Mr. S. Eric Osborn.

MR. A. J. BEANLAND, B.Sc., A.M.I.E.E., has been appointed assistant general manager at the Trafford Park works of Lancashire Dynamo and Crypto (Mfg.), Ltd.

MR. A. J. BOURNE has been elected a director of Earle, Bourne and Co., Ltd., Heath Street South, Birmingham, 18. He has been works manager of the company for the last twenty-seven years.

THE ENGLISH ELECTRIC COMPANY, Ltd., states that Sir John H. Woods will shortly take up an appointment in its organisation. Sir John has been Permanent Secretary of the Board of Trade since 1945.

A. REYROLLE AND CO., Ltd., Hebburn, announces that Mr. F. N. Prangnell has now returned to his headquarters at 12, Mission Row, Calcutta, to take over the company's representation in India, Pakistan, Burma, and Ceylon.

THE BRITISH ELECTRICITY AUTHORITY announces the appointment of Mr. A. H. Marsh, A.M.I.E.E., as generation engineer (construction) in the South-East Scotland division, in succession to Mr. J. Hagen, A.M.I.E.E., who has retired.

THE BRITISH ELECTRICITY AUTHORITY states that Mr. G. R. Peterson, B.A., M.I.E.E., has been appointed generation operation engineer in the chief engineer's department, in succession to Mr. J. A. Vice, A.M.I.E.E., who has retired.

SIR ROBERT S. JOHNSON has resigned, on medical advice, from the office of managing director of Cammell Laird and Co., Ltd. He will retain the chairmanship of the company, and is succeeded as managing director by his son, Mr. R. W. Johnson.

CHANCE BROTHERS, Ltd., states that Mrs. R. Desbrow has been appointed press officer in succession to Miss Rosemary Garland, who has resigned on account of ill-health. Mrs. Desbrow will operate from the company's London office at 28, St. James's Square, S.W.1, the telephone number of which has been changed to Whitehall 6002.

MR. J. B. SCOTT, general sales manager of the plant division of Crompton Parkinson, Ltd., has been appointed an executive director of the company, and will become assistant sales director (home) on October 1st. Mr. C. A. J. Martin is to succeed to the position of general sales manager, plant division, and Mr. R. V. Powditch will become product sales manager, F.H.P. motors.

LONDON TRANSPORT announces that Mr. C. E. Dunton, formerly technical planning officer, has been appointed civil engineer; Mr. K. Brinsmead has been appointed assistant civil engineer (permanent way), responsible for all matters relating to the design, construction and maintenance of permanent way, and Mr. H. Raine has been appointed assistant civil engineer (general), responsible for matters relating to technical investigations, accounts, contracts and staff in the chief engineer's department.

British Patent Specifications

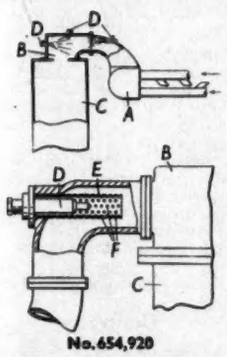
When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery Lane, W.C.2, 2s. each.

INTERNAL COMBUSTION ENGINES

654,920. December 20, 1948.—Pressure-Charged Diesel Engine Installations Incorporating Steam Generators or Water Heaters, The National Gas and Oil Engine Company, Ltd., of Ashton-under-Lyne, Lancaster, and Joseph Jones, of the company's address.

The invention consists of a pressure-charged diesel engine installation including a steam generator or water heater, heated by the combustion of fuel oil in a gas stream from the engine. Referring to the accompanying diagrammatic drawings, in the upper view, a turbo blower *A*, driven by exhaust gases from a diesel engine, is shown. The exhaust gases from the turbo blower are led to the combustion space *B* of a waste heat boiler *C* and one or more fuel injection nozzles *D* in the combustion chamber are provided. If the oil spray is directed into the flow of the exhaust gases the



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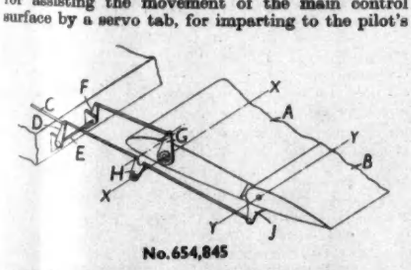
spray velocity is higher than the flame velocity and the flame is carried away from the nozzle. To overcome this difficulty, as shown in the lower view, each nozzle *D* is fitted with a pipe *E* having holes *F* in the wall, to admit the exhaust gases at a reduced velocity, so enabling the combustion to take place within reasonable distance of the injection nozzle. The flame, after leaving the tube *E* over the nozzle, meets the exhaust gases with the surplus air outside the tube for completion of combustion. The heat generated by combustion in the chamber raises the temperature of the water in the waste heat boiler. When a diesel engine is not supercharged by a turbo blower the exhaust gases from the engine are led direct to the combustion chamber of the waste heat boiler. In the case of a mechanically blown supercharged engine, where there is a constant quantity of air, the amounts of fuel admitted through the nozzles may be adjusted in order to obtain an approximately constant temperature in the waste heat boiler.—*July* 4, 1951.

AERONAUTICAL ENGINEERING

654,845. November 21, 1947.—Operation of Aircraft Control Surfaces, The Fairey Aviation Company, Ltd., of North Hyde Road, Hayes, Middlesex. (*Inventor: Charles Reginald Churn*).

Objects of the invention are to provide means for assisting the movement of the main control surface by a servo tab, for imparting to the pilot's



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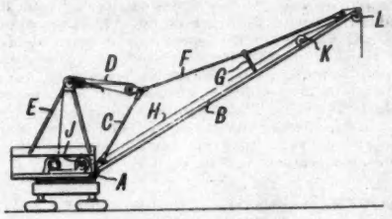
manual control a load proportional to the displacement of the control surface, and for enabling the main control surface to self-centre. In the accompanying drawing, the means for assisting the movement of the main control surface *A* by a servo tab *B* has a pilot's manual control and a run of linkage *C* connected with a first lever arm *D* mounted fast on a transverse shaft *E* in brackets just forward of the control surface. At the other end of the shaft is a second fixed lever arm *F*, connected by a link with a third lever arm *G*, secured to the control surface and coaxial with its hinge axis *x*—*x*. By these means the control surface may be actuated by the manual control through the linkage *C*. Coaxial with the third lever arm *G*, but rotatable independently of it, is a rocking lever *H*, shorter in length than the lever arm *G* and connected with the first lever arm *D* by means of a link and by means of a link with a fourth lever arm *J* secured to the tab *B* on the control surface and coaxial with the hinge axis *y*—*y* of the tab. When the main linkage *C* is operated to move the control surface *A* in a given direction, the tab *B* is moved in the opposite direction and thus acts as a servo to assist in overcoming the load imposed by the control surface. In another embodiment shown, a mechanical, irreversible unit, as described in the specification 636,506, is employed.—*July* 4, 1951.

CRANES AND LIFTING APPLIANCES

655,001. August 20, 1948.—Suspension of Crane Booms, Ruston-Bucyrus, Ltd., of Excavator Works, Lincoln, England (Assignees of Knut Edward Grundvig).

The invention relates to improvements in the suspension of crane booms, more particularly for the very long booms on dragline excavators.

Referring to the drawing, *A* is the main frame of a crane with a boom *B*. Also pivoted to the front of the main frame and extending upward at a steeper inclination, are tension members *C*, which are supported by boom-hoist ropes *D*, from the top of a frame *E* on the main frame and by fixed-length guys *F* extending from the top of the members to the outer end of the boom. The A-frame is of such height that members *C* are in tension for all positions of the boom. Short suspender members *G* support approximately



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the middle of the boom from guys *F* and are preferably of such length that they will straighten out the initial sag of the boom. The hoist-rope runs from a winch *J* on the main frame, over a sheave *K* on the boom, thence over a sheave *L* at the outer end of the boom and downwards to the load. By substituting tension members *C*, the upper ends of which are always below the straight line between the top of the A-frame and the outer end of the boom, for the conventional mast and A-frame, the weight of the front end has been greatly reduced. The weight of the A-frame has been increased to a lesser extent, thereby effecting a net decrease in weight and a backward relocation of the centre of gravity of the whole machine, to reduce the moment of momentum, without losing the advantage of the fixed anchorage for the guys *F* and suspender members *G* in all positions of the boom. The invention is equally applicable to other types of boom and other types of suspenders.—*July* 4, 1951.

AUTOMOBILE ENGINEERING

654,889. June 10, 1948.—Vehicle Brakes, Girling, Ltd., of King's Road, Tyseley, Birmingham, 11 (*Inventor: Gabriel Andrew George Fazekas*).

In the drawing are shown two identical shoes *A* and *B*, provided with friction linings and mounted on a back-plate *C* within a rotatable drum. This may rotate in either direction and one shoe will act as a leading shoe and the other as a trailing shoe according to the direction of rotation. The shoes abut at one end on parallel surfaces on a double-ended hydraulic wheel cylinder *D*, by which they are separated to apply the brake, and at their other ends they abut on the inclined surfaces *E* of a stationary abutment *F* on which the shoes can slide and rock. The shoes are adapted to be adjusted for wear of the linings by the usual snail cams *G*. If the drum is rotating in the direction indicated by the arrow the shoe *A* is a leading shoe and, by selection of a suitable angle for the surface *E* in relation to the coefficient of friction of the shoe lining and its length and disposition on the shoe, it is a simple matter to ensure that the wear of the lining is substantially uniform throughout its length. However, the shoe *B* is a trailing shoe and, under the drag of the drum when the brake is applied, it will be urged upwards towards the wheel cylinder so that the end of the lining nearest the cylinder will be more heavily loaded and will wear more rapidly than the other end. According to the invention this uneven wear is avoided by providing a third abutment for the shoe *B*, which prevents it from sliding upwards towards the wheel cylinder. This abutment comprises a peg *H* mounted on the back-

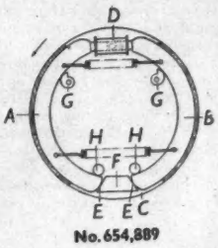

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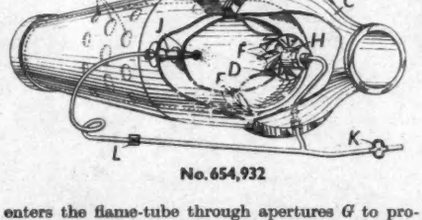
plate immediately above the inner edge of the shoe web adjacent to the lower end of the shoe. Thus, when the brake is applied, the shoe engages the wheel cylinder and the peg, which prevents it from moving upwards towards the wheel cylinder but allows it to move bodily outwards into engagement with the drum. If the direction of rotation of the drum is reversed the peg does not interfere in any way with the freedom of the shoe to slide downwards in engagement with the surface on the abutment. A second peg is provided for engagement by the shoe *A*, which will act as a trailing shoe when the direction of rotation of the drum is reversed. Some modifications in the arrangement of the abutments are also shown in the specification.—*July* 4, 1951.

GAS TURBINES

654,932. September 9, 1946.—Combustion-Chambers for Gas-Turbines, Rolls-Royce, Ltd., of Nightingale Road, Derby (*Inventor: Francis Murray Johnson*).

This invention is intended to provide an improved construction and arrangement of burners to avoid the risk of accidental extinction and ensure continuity of the flame under all operating conditions. As shown in the drawing, the combustion chamber comprises an air-casing *A* with a flame-tube *B* mounted within. Air enters the casing through a neck *C* and flows through the combustion chamber. Part of the air passes into the flame-tube through a central port *D* in a domed end and, with air flowing through apertures *E*, provides primary combustion air. Swirl vanes *F* in the port *D* are provided to assist in ensuring effective mixing of air and fuel. The remainder of the air flows between the air-casing and the flame-tube *B* and of this air part



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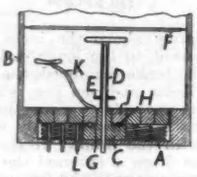
enters the flame-tube through apertures *G* to provide secondary air. In accordance with the invention, to avoid the risk of accidental extinction of the flame, a pilot-atomising jet *H* having a low flow factor, is mounted in the primary air inlet port *D* and a main jet *J*, which has a high flow factor, is mounted in the side wall of the combustion chamber towards the outlet end of the chamber. The main jet is arranged to deliver its spray of fuel against the direction of air-flow through the flame-tube. Both the jets are supplied with fuel from a pump *K* through a pipeline, and a spring-loaded valve *L* is included in the main fuel-jet supply pipeline to maintain the pressure at the pilot jet *H* at a predetermined figure above the pressure at the main fuel-jet *J*. In use both jets deliver fuel under all operating conditions. When, however, the fuel-delivery pressure falls below a certain value, for example, under idling conditions or low-throttle conditions at high altitude, the atomisation of the fuel at the main fuel-jet may cease but extinction of the flame does not occur because the pilot-jet continues to function due to the low flow-factor of its burner and also to the higher delivery pressure in the pilot-jet pipeline. The arrangement is applicable to a pure jet-propulsion engine, but is also particularly

advantageous for use with a combined air-screw and jet propulsion engine, since in the latter case windmilling of the air-screw may produce a very wide range of air-to-fuel ratio, which increases the difficulty of maintaining continuity of the flame.—*July* 4, 1951.

CRANES, TRUCKS AND EXCAVATORS

654,966. December 30, 1947.—MANŒUVRING DEVICE, Gunnar Preben Bjorn Atlung, of Sorgenfri vej 10, Lyngby, Denmark.

The invention relates to a manœuvring device for cranes, transporting trucks or vessels, excavators and similar machines that are provided with a cabin, a platform or a seat for the operator, rotatable about a steering gear. The driver's cabin shown in the drawing comprises a floor *A* and walls *B*. In the floor is a central bearing *C*, which carries a tubular extension projecting up into the cabin. This extension encompasses a steering shaft *D*. Near the floor the extension carries two footrests *E*. A rail-bar *F* is fixed in a suitable position within



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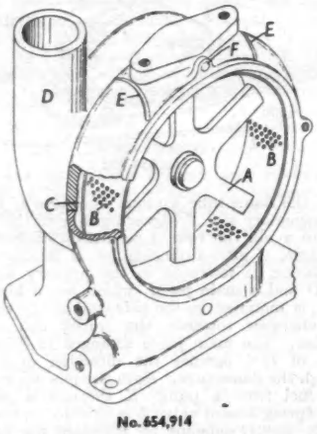
the cabin. The bearing has an annular shoulder *G* in its upper surface with a race for the balls *H* of a bearing supporting the innermost ring *J* of a number of coaxially disposed rings. The innermost ring carries a seat *K* and the other rings are each supported by compression springs, and each bears upon a pedal *L*. The pedals are arranged for operating a brake, a clutch and a fuel regulator, for the machine to be driven. An operator in the seat can, by pressing against either the foot rests or the rail, cause the ring *J* to revolve, together with the seat, to any desired position around the bearing. In any such position he may, by pressing the rings with his foot operate the pedal members. A modification showing the operating rings approximately semi-circular, arranged for oscillation on shafts extending at a right angle to the steering-wheel shaft is also illustrated in the specification.—*July* 4, 1951.

AGRICULTURAL ENGINEERING

654,914. November 10, 1948.—ROTARY HAMMER MILL, E. H. Bentall and Co., Ltd., of Heybridge Works, Maldon, Essex (*Inventor, Arthur Arnold Edwin Jolly*).

This invention relates to rotary hammer mills suitable for pulverising grain. In operation the grain drops directly into the centre of the rotor



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chamber, where it is pulverised by the rotor arms *A*. The grain particles are drawn by suction through the screen holes *B* into the annular suction chamber *C*, whence they pass into the discharge pipe *D*. Any tendency of the material in the chamber to accumulate and form solid balls or pockets of materials is prevented by the stream of secondary air which enters through slots *E* and holes *F* so providing currents of air which by sweeping around the annulus prevent the pulverised material adhering to the walls.—*July* 4, 1951.

British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 24, Victoria Street, London, S.W.1.

WROUGHT PIPE FITTINGS, IRON AND STEEL (SCREWED B.S.P. THREAD)

No. 1740 : 1951. This recently published standard covers an extensive range of fittings, screwed with British Standard Pipe Thread, for use with wrought steel and wrought iron pipes and includes, for the convenience of users, particulars of equal sockets, hexagonal backnuts and barrel nipples, as specified in B.S. 788 and B.S. 1387. Two standard weights of fittings are specified, namely, light weight and heavy weight, except where otherwise shown.

It covers welded and seamless wrought steel and wrought iron pipe fittings of nominal sizes ⅛in to 6in, inclusive, for use with steel tubes to B.S.1387 and wrought iron tubes to B.S.788. Pressure tests are prescribed. An appendix is included covering a mechanical expansion test on the fittings. Price 5s.

GRUB SCREWS FOR AERONAUTICAL PURPOSES

Nos. A.55 and A.56 : 1951. These British Standards on grub screws for aeronautical purposes cover the material, dimensions and finish of grub screws in free-cutting and in stainless steel. Price 1s. each.

MOTORS FOR BATTERY-OPERATED VEHICLES

No. 1727 : 1951. Because of the increasing use of battery-operated vehicles the British Standards Institution has recently published a British Standard for motors for battery-operated vehicles. It covers the classification, rating and methods of test for d.c. electric motors forming part of the equipment of battery-operated road vehicles, industrial trucks and tractors, but it does not apply to rail vehicles. The specification gives details of types of motor, temperature tests, over-speed tests, commutation tests, high voltage tests, efficiency, characteristic curves and performance and type tests. The appendices include classification of insulating materials, methods of determining efficiency, terminal markings and recommended limits of temperature in service. Price 3s.

WOVEN ASBESTOS BINDING TAPE FOR ELECTRICAL PURPOSES

No. 1720 : 1951. This British Standard applies to plain, unimpregnated woven asbestos tape, having selvedges suitable for binding purposes for electrical apparatus. It does not include tapes having an all-cotton weft or warp or the grade of tape for electrical insulating purposes for which another British Standard is in course of preparation. It recommends the identification of such binding tape by green-coloured warp threads woven into the centre of the tape or selvedges. It includes details of finish, length, thickness, width and the number of threads, and the appendices deal with methods of conditioning specimens for test, determination of the length of a roll, of thickness, of width, of cotton content, of conducting inclusions and, in addition, methods of test for ageing and tensile strength. Price 2s.

FLANGED CAST IRON GATE VALVES, CLASSES 125 and 250 FOR THE PETROLEUM INDUSTRY

No. 1735 : 1951. This British Standard is one of a series that is being prepared for the petroleum industry. It covers flanged cast iron gate valves with either wedge gates or double disc gates and having either outside screw-and-yoke rising stems or inside screw non-rising stems, the seat rings being either separate or an integral part of the body wedge or discs. The permissible pressure is a maximum of 400 lb per square inch for liquid and gas at about atmospheric pressure and 250 lb per square inch for saturated steam for valves 14–24in in size. The standard includes provisions relating to design and manufacture, materials, workmanship, marking, tests, inspection, despatch and guarantee. The specification is supported by a number of appendices and four detailed drawings illustrating the valves covered and providing identification of the various parts of the valves. Price 5s.

STEEL PIPES AND FLANGED JOINTS FOR HYDRAULIC PURPOSES

No. 778 : 1951. This British Standard supersedes B.S. 778 : 1938, "Steel-Flanged Joints for Hydraulic Pipelines," which was limited in its scope to flanged joints for pipelines for working pressures up to 4500 lb per square inch and included only recommended minimum thicknesses in respect of pipes for such pipelines. The scope of the new British Standard embraces complete specifications for both flanges and pipes for working pressures up to 4500 lb per square inch and the types of flanges standardised are suitable not only for pipelines but also for use on valves and hydraulic machines.

The basic principle adopted for the joint is that standardised in the 1938 edition, namely, to have flanges screwed on the pipes, fitting freely, and serving the sole function of drawing the pipes together. The resulting joint is thus made on a ductile joint ring between the ends of the pipes themselves. Particulars are given of butt-welded steel pipes, seamless steel pipes, surface protection and flanged joints. Tables of dimensions of pipes, and of oval, rectangular, square and round flanges are included, and the appropriate design pressure range, for each type of flange, is specified. An appendix has also been included relating to bituminous protection. Price 4s.

Codes of Practice

The Council for Codes of Practice for Buildings—Construction and Engineering Services, is under the aegis of the Ministry of Works. Codes are issued on behalf of the Committee by the British Standards Institution, 24–28, Victoria Street, London, S.W.1.

BOILERS FOR CENTRAL HEATING BY HOT WATER

Code 332.303. The Council for Codes of Practice for Buildings has now published in final form Code 332.303, "Installation of Gas-Fired Boilers for Central Heating by Hot Water." The code includes consideration of points appropriate to boilers required to provide hot water for domestic purposes in addition to space heating. The design of space heating and domestic hot water systems is dealt with in other codes. The code was previously issued as a draft for comment and has now been revised by a committee convened on the Council's behalf by the Institution of Gas Engineers. Price 3s.

Contracts

VICKERS-ARMSTRONGS, Ltd., has received an order for a 2600-ton destroyer for the Venezuelan Navy, to be built at the company's Barrow yard.

PHILIP AND SON, Ltd., is to build a diesel-electric pilot vessel, for the Mersey Docks and Harbour Board, similar to the "Sir Thomas Brocklebank," the main machinery being supplied by the General Electric Company, Ltd.

THE BURNTISLAND SHIPBUILDING COMPANY, Ltd., is to build two motor cargo vessels, each of 10,500 tons deadweight, for the Fomentador Compania Naviera S.A. Panama. The propelling machinery will consist of Kincaid-Burmeister and Wain diesel engines of 5500 b.h.p. The company has also contracted to build a motor cargo vessel of 10,500 tons deadweight for the Tramp Chartering Corporation, of Panama. The ship will be propelled by a Kincaid-Burmeister and Wain diesel engine of 5500 b.h.p.

HENRY ROBB, Ltd., is to build a cargo motorship of 5500 tons deadweight, propelled by a 2000 b.h.p. Sulzer diesel engine, for the Rodney Steamship Company, Ltd. The company will also build for A. F. Henry and MacGregor, Ltd., a 2250 tons deadweight cargo ship driven by an eight-cylinder British Polar diesel engine of 1280 b.h.p., and a motorship of 900 tons deadweight with a four-cylinder British Polar diesel engine of 640 b.h.p.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Stephenson Locomotive Society

Sat., Aug. 11th.—SCOTTISH CENTRE: Visits to Motherwell and Hamilton Running Sheds, 2.30 p.m.

Sat., Aug. 18th.—Visits to Motive Power Depots (London and Southern), Stratford, (North Eastern) Gateshead, (North Western) Bolton and Bury, (Scottish) St. Margarets, 2.30 p.m.

Sun., Aug. 19th.—Visit to Swindon Locomotive Works and Running Sheds, from 1.30 p.m.

Sat., Aug. 25th.—Lineside Traffic Observation, Bromsgrove and Lickey Incline, L.M. and W. Regions, from 2 p.m.